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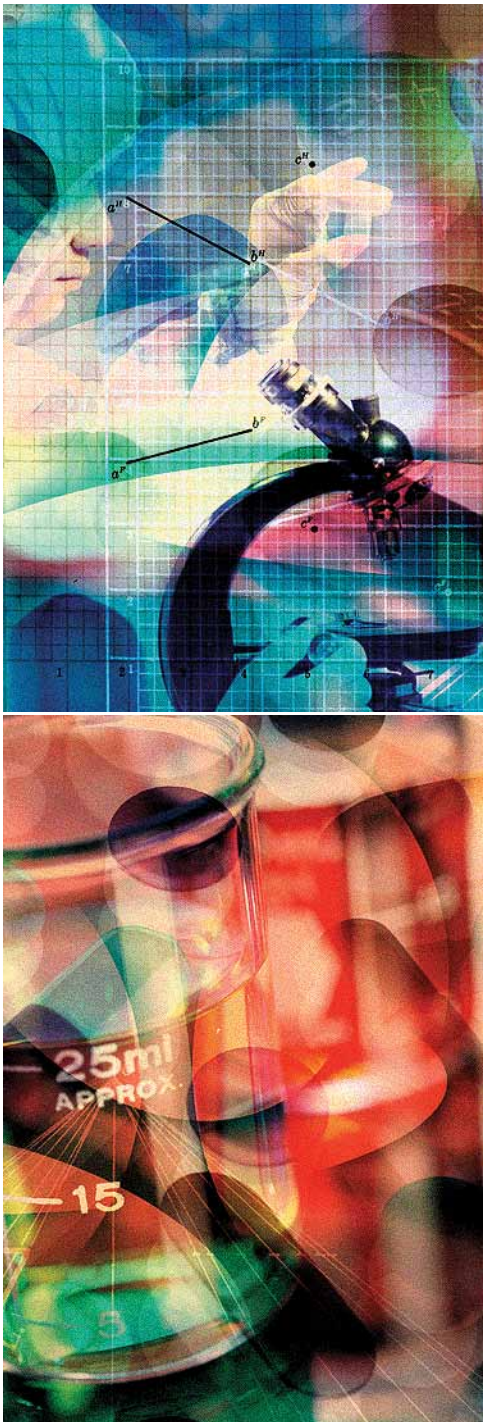

Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)

...working towards the preservation of effective antimicrobials for humans and animals...

Annual Report

2008

Canada

Healthy Canadians and communities in a healthier world
— Public Health Agency of Canada

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...working towards the preservation of effective antimicrobials for humans and animals...

2008

Contributors to CIPARS 2008

These acknowledgements are intended to identify and thank the numerous individuals and organizations that have contributed to the success of CIPARS 2008.

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3 National Microbiology Laboratory

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Abattoir-Industry Participants

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Farm Surveillance Participants

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Other Participants

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Canadian Committee on Antibiotic Resistance
Canadian Meat Council
Canadian Pork Council
Canadian Poultry and Egg Processors Council
CIPARS National Steering Committee on Antimicrobial Resistance Surveillance in Enterics
CIPARS Farm Swine Advisory Committee

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Executive Summary

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) tracks temporal and regional trends in antimicrobial use and antimicrobial resistance in selected species of enteric bacteria obtained at different stages of food production and from human clinical laboratory submissions. This information supports the creation and evaluation of policies to contain antimicrobial resistance and to better manage antimicrobial use in human medicine, veterinary medicine, and agricultural sectors. CIPARS highlights antimicrobials considered to be of very high importance in human medicine (Category I of the antimicrobial classification system of the Veterinary Drugs Directorate, Health Canada), such as ceftriaxone and ciprofloxacin. CIPARS has now adopted the new resistance breakpoint of 4 µg/mL for ceftriaxone, resulting in an increase in reported ceftriaxone resistance that now closely parallels ceftiofur resistance.

Among the 3,601 human clinical isolates submitted for susceptibility testing in 2008, the 3 most commonly detected *Salmonella* serovars were Enteritidis, Typhimurium, and Heidelberg. Resistance to the Category I antimicrobial, ceftriaxone (and generally cross-resistance to ceftiofur and amoxicillin-clavulanic acid) among *S.* Heidelberg isolates (14%) remained higher than other serovars. The percentage of isolates with reduced susceptibility or resistance to ciprofloxacin ranged from 0% to 3%, with the exception of serovars Paratyphi A (89%), Typhi (72%), and Enteritidis (14%).

Reduced susceptibility or resistance to ciprofloxacin was not detected in any *Salmonella* isolates from abattoir or retail meat samples. However, reduced susceptibility to ciprofloxacin was detected in *Escherichia coli* recovered from samples of abattoir chickens, retail chicken, farm pigs, abattoir pigs, and retail pork (all ≤ 5%) but not in samples from abattoir beef cattle or retail beef. Full ciprofloxacin resistance was detected in less than 5% of *Campylobacter* isolates from abattoir beef cattle; *Campylobacter*, *E. coli* and *Enterococcus* isolates from retail chicken; *E. coli* isolates from retail pork; and *Enterococcus* isolates from farm pigs. In retail chicken from British Columbia and Saskatchewan, resistance to ciprofloxacin in *Campylobacter* was found in 8% and 10%, of isolates respectively.

The retail component of CIPARS is designed to examine inter-provincial differences in human exposure to antimicrobial resistance. For retail beef and pork, there were no significant differences among the provinces in percentages of isolates with antimicrobial resistance. However, for retail chicken, statistically significant ($P \leq 0.05$) differences across provinces/region were observed for resistance in *E. coli*, with higher percentages of isolates from British Columbia resistant to amoxicillin-clavulanic acid, ampicillin, cefoxitin, ceftiofur, and ceftriaxone than from Saskatchewan, Ontario, Québec, or the Maritimes region (except for ceftriaxone). The percentage of *E. coli* isolates from retail chicken with resistance to gentamicin was significantly higher for Québec than for British Columbia. Percentages of chicken *E. coli* isolates with resistance to sulfisoxazole and trimethoprim-sulfamethoxazole were significantly higher for Québec than for Saskatchewan.

Important temporal variations in antimicrobial resistance were also identified in retail chicken. The percentage of *E. coli* isolates from Saskatchewan with resistance to ceftiofur was significantly higher in 2008 than in 2007 or 2005 (first year of surveillance). Ceftiofur resistance was also higher in 2008 than in 2006 (last year of ceftiofur voluntary withdrawal) in chicken from Québec. The significant increase in retail chicken *E. coli* isolates from Québec with resistance to ceftiofur may have resulted from the resumption of extra-label ceftiofur use by broiler chicken hatcheries in 2007. A greater percentage of retail chicken *E. coli* isolates from Québec had resistance to nalidixic acid in 2008 than in 2003. The percentage of retail chicken *Campylobacter* from Ontario with resistance to azithromycin was also significantly higher in 2008 than in 2007. Vancomycin resistance was not detected in any *Enterococcus* isolates obtained from retail chicken and farm pigs.

With respect to human antimicrobial use, overall consumption in 2008 decreased, as measured by prescription dispensing rates and defined daily doses (DDDs)/1,000 inhabitant-days, to one of the lowest levels observed during the 9-year surveillance period. Category I antimicrobials continued to represent a high percentage (17%) of the total DDDs dispensed. There were provincial differences with respect to antimicrobial consumption, including differences in the consumption of fluoroquinolones, penicillins with extended spectrum, and macrolides, among others. When the total amount of oral antimicrobials dispensed in 2007 was compared with the total outpatient antimicrobial use in 19 European countries in the same year, Canada ranked 9th out of the 20 countries classified by increasing level of total antimicrobial consumption.

For antimicrobial use in animals, surveillance of sentinel swine herds (grower-finisher pigs) in 2008 revealed that the most commonly used antimicrobials belonged to Categories II or III (macrolides, lincosamides, penicillins, and tetracyclines). The only Category I antimicrobial used in animals was ceftiofur, which was administered via injection to individual animals in 21% of the herds. At the herd level, an 8% decrease in ceftiofur use since 2007 was evident. Data from the Canadian Animal Health Institute regarding total kilograms of veterinary antimicrobials distributed for sale for all animals indicated a total of 1,615,571 kg was distributed in 2008. This represents a decrease of 9% relative to the total distributed in 2006 and a less than 1% decrease relative to the 2007 total. The quantity of fluoroquinolones distributed for use in animals in 2008 decreased by 30% relative to the 2006 total and by 7% relative to the 2007 total.

CIPARS is continually evolving to provide a better understanding of antimicrobial resistance in Canada, including discussions of farm surveillance of antimicrobial use and antimicrobial resistance in the broiler poultry sector. CIPARS also functions as a research platform, with involvement in projects studying aspects of use and resistance not covered by routine surveillance, such as additional populations (i.e. companion animals, sheep, wild small mammals, and subpopulations of people in Canada), additional regions (i.e. retail sampling in Alberta), and additional bacterial species of concern (i.e. methicillin-resistant *Staphylococcus aureus* and *Clostridium difficile*). Short abstracts from selected research projects are presented in this report.

Summary of antimicrobial resistance surveillance findings for bacterial isolates from humans and the agri-food sector, 2008.

Species	Bacterial species	Number (%) of isolates resistant				
		Resistance to 1 or more antimicrobials	Resistance to 5 or more antimicrobials[a]	Resistance to Category I[b] antimicrobials	Resistance to NAL or reduced susceptibility to CIP	Number of different resistance patterns / number of isolates resistant
Surveillance of Human Clinical Isolates						
Human	*Salmonella*	950/3,601 (26%)	264/3,601 (7%)	AMC: 77/3,601 (2%) TIO: 79/3,601 (2%) CRO: 79/3,601 (2%) CIP: 11/3,601 (< 1%)	NAL: 402/3,601 (11%) RSCIP: 429/3,601 (12%)	118/950
Farm Surveillance						
Pigs	*Salmonella*	38/61 (62%)	14/61 (23%)			13/61
	Escherichia coli	1,231/1,425 (87%)	170/1,425 (12%)	AMC: 17/1,425 (1%) TIO: 15/1,425 (1%) CRO: 18/1,425 (1%)	NAL: 5/1,425 (< 1%) RSCIP: 3/1,425 (< 1%)	87/1,425
	Enterococcus	1,213/1,266 (96%)	500/1,266 (39%)	CIP: 25/1,266 (2%) DAP: 1/1,266 (<1%) TIG: 22/1,266 (2%)	N/A	97/1,266
Abattoir Surveillance						
Beef cattle	*Escherichia coli*	69/176 (39%)				13/69
	Campylobacter	86/128 (67%)	2/128 (2%)	RCIP: 3/128 (2%)	N/A	4/86
Chickens	*Salmonella*	121/234 (52%)	28/234 (12%)	AMC: 27/234 (12%) TIO: 27/234 (12%) CRO: 27/234 (12%)		17/121
	Escherichia coli	131/170 (77%)	52/170 (31%)	AMC: 45/170 (26%) TIO: 34/170 (20%) CRO: 39/170 (23%)	NAL: 6/170 (4%) RSCIP: 5/170 (3%)	63/131
Pigs	*Salmonella*	96/151 (64%)	36/151 (24%)	AMC: 2/151 (1%) TIO: 1/151 (1%) CRO: 1/151 (1%)		22/96
	Escherichia coli	133/150 (89%)	20/150 (13%)	AMC: 1/150 (1%) TIO: 1/150 (1%) CRO: 1/150 (1%)	NAL: 1/150 (1%) RSCIP: 1/150 (1%)	37/133
Retail Meat Surveillance						
Beef	*Escherichia coli*	128/572 (22%)	12/572 (2%)	AMC: 7/572 (1%) TIO: 7/572 (1%) CRO: 7/572 (1%)		35/128
Chicken	*Salmonella*	180/382 (47%)	49/382 (13%)	AMC: 46/382 (12%) TIO: 48/382 (13%) CRO: 48/382 (13%)		28/180
	Escherichia coli	336/479 (70%)	147/479 (31%)	AMC: 136/479 (28%) TIO: 119/479 (25%) CRO: 137/479 (29%) CIP: 1/479 (< 1%)	NAL: 26/479 (5%) RSCIP: 26/479 (5%)	90/336
	Campylobacter	129/264 (49%)	24/264 (9%)	CIP: 13/264 (5%)	N/A	9/129
	Enterococcus	428/464 (92%)	95/464 (20%)	CIP: 6/464 (1%)	N/A	47/428
Pork	*Salmonella*	25/36 (69%)	6/36 (17%)	AMC: 1/36 (3%) TIO: 1/36 (3%) CRO: 1/36 (3%)		15/25
	Escherichia coli	134/317 (42%)	27/317 (9%)	AMC: 9/317 (3%) TIO: 9/317 (3%) CRO: 9/317 (3%) CIP: 1/317 (< 1%)	NAL: 4/317 (1%) RSCIP: 3/317 (1%)	48/134
Surveillance of Animal Clinical Isolates						
Cattle	*Salmonella*	52/134 (39%)	38/134 (28%)	AMC: 6/134 (4%) TIO: 6/134 (4%) CRO: 6/134 (4%)	RSCIP: 1/134 (1%)	20/52
Pigs	*Salmonella*	113/158 (72%)	61/158 (39%)	AMC: 2/158 (1%) TIO: 2/158 (1%) CRO: 2/158 (1%)		29/113
Chickens	*Salmonella*	66/209 (32%)	35/209 (17%)	AMC: 33/209 (16%) TIO: 34/209 (16%) CRO: 34/209 (16%)		18/66
Turkeys	*Salmonella*	29/32 (91%)	19/32 (59%)	AMC: 18/32 (56%) TIO: 18/32 (56%) CRO: 18/32 (56%)		14/29
Horses	*Salmonella*	34/62 (55%)	32/62 (52%)	AMC: 7/62 (11%) TIO: 7/62 (11%) CRO: 7/62 (11%)	RSCIP: 25/62 (40%)	8/34
Feed and Feed Ingredients						
	Salmonella	6/57 (11%)	3/57 (5%)	AMC: 1/57 (2%) TIO: 1/57 (2%) CRO: 1/57 (2%)		7/6

Blank cells represent values equal to zero (0%).

AMC = Amoxicillin-clavulanic acid. CIP = Ciprofloxacin. NAL = Nalidixic acid. QDA = Quinupristin-dalfopristin. TIO = Ceftiofur.

RSCIP = Reduced susceptibility to ciprofloxacin. CRO = Ceftriaxone. DAP = Daptomycin. TIG = Tigecycline. N/A = Not applicable.

[a] Resistance to 3 or more for *Campylobacter* isolates.

[b] Categorization of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate of Health Canada (Appendix A).

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Preamble

About CIPARS

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS), created in 2002, is a national program dedicated to the collection, integration, analysis, and communication of trends in antimicrobial use and resistance in selected bacteria from humans, animals, and animal-derived food sources across Canada. This information supports (i) the creation of evidence-based policies for antimicrobial use in hospitals, communities, and food-animal production with the aim of prolonging the effectiveness of these drugs and (ii) the identification of appropriate measures to contain the emergence and spread of resistant bacteria among animals, food, and people. This publication represents the 7th annual CIPARS report released by the Government of Canada under the coordination of the Public Health Agency of Canada.

CIPARS Objectives

- Provide a unified approach to monitor trends in antimicrobial resistance and antimicrobial use in humans and animals.
- Disseminate timely results.
- Generate data to facilitate assessment of the public health impact of antimicrobials used in humans and agricultural sectors.
- Provide data that allow accurate comparisons with data from other countries that use similar surveillance systems.

CIPARS 2008 Activities

In 2008, CIPARS included 2 passive and 3 active antimicrobial resistance surveillance components, as well as antimicrobial use surveillance in humans and animals (Figure 1).

Surveillance of Antimicrobial Resistance

- *Surveillance of Human Clinical Isolates* involved passive surveillance of human clinical *Salmonella* isolates at the provincial/territorial level and participation of all Provincial Public Health Laboratories across the country.
- *Retail Meat Surveillance* involved active sample collection and antimicrobial susceptibility testing of generic *Escherichia coli*,[1] *Enterococcus*, *Salmonella*, and *Campylobacter* in retail chicken, and of *E. coli* in beef and *Salmonella* and *E. coli* in pork from British Columbia, Saskatchewan, Ontario, Québec, and the Maritimes region (New Brunswick, Nova Scotia, and Prince Edward Island). *Campylobacter* and *Enterococcus* isolates recovered from retail chicken in the Maritimes region underwent antimicrobial susceptibility testing, but results are not presented in this report because of concerns surrounding harmonization of laboratory methods for 2008 only.
- *Abattoir Surveillance* involved active sample collection of ceacal content and antimicrobial susceptibility testing of *Salmonella* and generic *E. coli* of healthy chickens and pigs and of *Campylobacter* and generic *E. coli* from healthy beef cattle across Canada.
- *Farm Surveillance* involved swine herds in the 5 major pork-producing provinces in Canada (Alberta, Saskatchewan, Manitoba, Ontario, and Québec). A sentinel farm framework was used to organize the active collection of pooled fecal samples from pigs and the isolation of generic *E. coli*, *Enterococcus,* and *Salmonella* isolates for antimicrobial susceptibility testing.

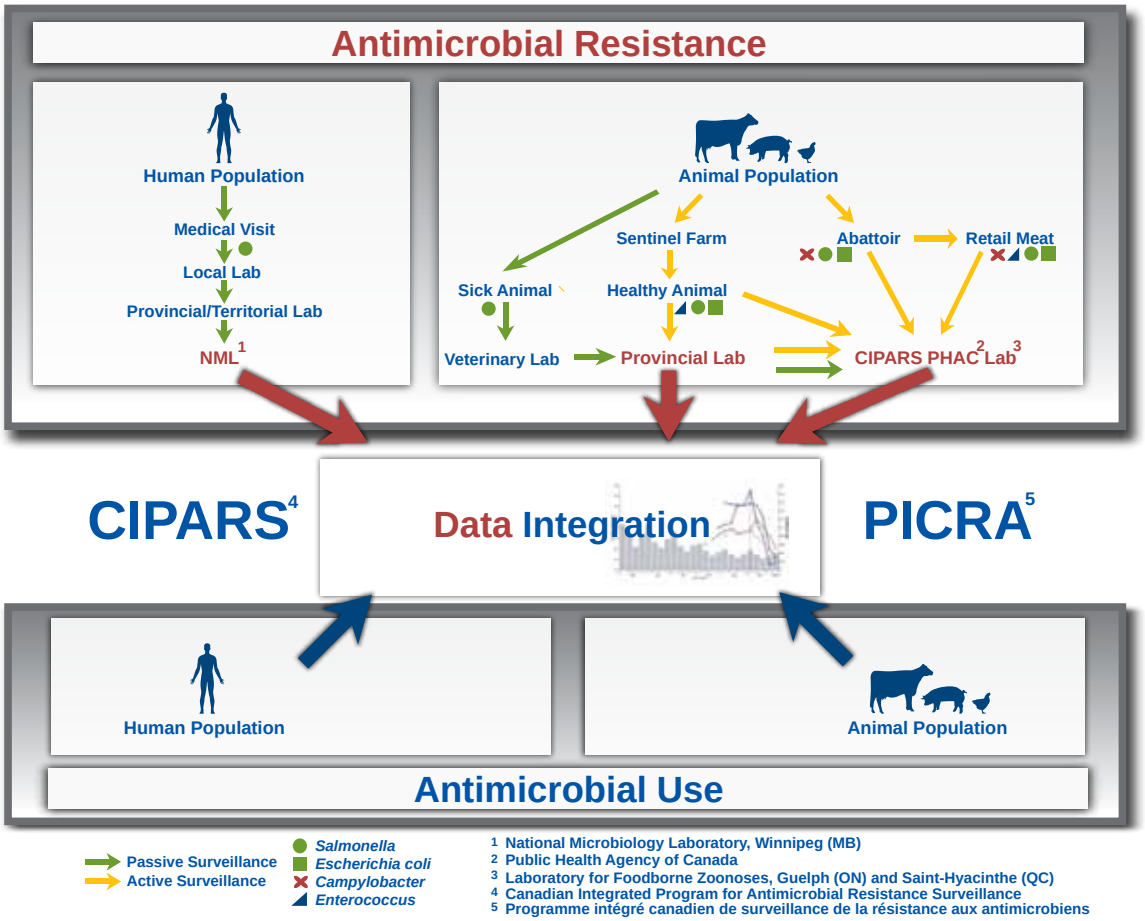
[1] *Escherichia coli* were identified by use of biochemical tests. No attempt was made to distinguish pathogenic strains of *E. coli* from non-pathogenic strains.

- *Surveillance of Animal Clinical Isolates* involved passive surveillance of clinical *Salmonella* isolates from animals in multiple provinces. Samples were originally submitted by veterinarians or producers to local or provincial laboratories and may have also included samples from animal feed, the animal's environment, or non-diseased animals from the same herd. Cattle isolates could be from either dairy or beef cattle, or from veal farms. Chicken isolates could be from either layer hens or broiler chickens.
- *Salmonella* isolates recovered from *Feed and Feed Ingredients* samples were obtained from Government and Industry Monitoring programs and from *passive surveillance*.

Surveillance of Antimicrobial Use

- Antimicrobial use surveillance in humans *included data obtained from the Canadian CompuScript and provided by Intercontinental Medical Statistics Health for 2000 through 2008. This dataset contains information on prescriptions dispensed by Canadian retail pharmacies.*
- Antimicrobial use surveillance in pigs included data obtained from the *Farm Surveillance* component of CIPARS through questionnaires completed by veterinarians, owners, or managers of the herds. Questionnaires captured information on antimicrobials used (in water, feed, and injections) within each herd, health status of pigs, and farm characteristics.
- Antimicrobial use surveillance in animals included data obtained from the Canadian Animal Health Institute and analysed by Impact Vet for 2006 through 2008. This dataset contains information on the total kilograms of antimicrobials distributed by Canadian companies for use in food, sporting, and companion animals and fish.

FIGURE 1. Diagram of CIPARS surveillance components in 2008.



What's New in the 2008 Report

Changes to CIPARS

- *Retail Meat Surveillance* began in the Maritimes region in September 2008.

Methodological Changes

- A more sensitive *Campylobacter* recovery method than was previously used was implemented for bacterial culture of caecal samples from abattoir beef cattle.
- The new resistance breakpoint of 4 µg/mL for ceftriaxone (Clinical and Laboratory Standards Institute [CLSI] M100-S20) was adopted and applied to the final 2008 *Salmonella* and *E. coli* data and all historical data. The previous breakpoint was 64 µg/mL. This change resulted in an increase in ceftriaxone resistance to levels now similar to those of ceftiofur resistance. In terms of reporting, we therefore no longer present results on intermediate susceptibility to ceftriaxone.
- Since the release of the 2008 preliminary CIPARS report, the revised version (April 2009) of the classification system of the Veterinary Drugs Directorate (VDD), Health Canada was adopted. This change resulted in the reclassification of quinupristin-dalfopristin as a Category II antimicrobial (High Importance in Human Medicine) instead of a Category I antimicrobial (Very High Importance in Human Medicine) for all *Enterococcus* isolates.

Periodic Reporting

- Antimicrobial resistance results are presented for *Salmonella* retail pork isolates received from 2003 through 2008.

Important Notes

Antimicrobial Groupings

- **Category of importance in human medicine:** Antimicrobials have been categorized on the basis of importance in human medicine in accordance with the classification system of the VDD, Health Canada (categories revised in April 2009; Appendix A).
  - All Category I antimicrobials (Very High Importance in Human Medicine) are highlighted throughout the report. These antimicrobials include amoxicillin-clavulanic acid, ceftiofur,[1] ceftriaxone, ciprofloxacin, daptomycin, linezolid, telithromycin, and vancomycin.
  - Antimicrobials are generally listed first according to this classification and then alphabetically.
- **ATC class:** For human antimicrobial use data, antimicrobials have been classified by the international standard Anatomic Therapeutic Chemical (ATC) class system[2] in addition to the category of importance in human medicine.
- **Canadian Animal Health Institute aggregate class:** Data on the distribution of antimicrobial use in animals were provided to CIPARS by the Canadian Animal Health Institute in aggregate antimicrobial classes as presented in this report.

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[1] Ceftiofur is licensed for use in animals only. Resistance to ceftiofur is generally detected in combination with resistance to amoxicillin-clavulanic acid, cefoxitin, ampicillin and ceftriaxone (A2C-AMP-CRO resistance pattern).

[2] World Health Organization. The Anatomical Therapeutic Chemical Classification System with Defined Daily Doses (ATC/DDD). Available at: www.who.int/classifications/atcddd/en. Accessed October 2010.

Labels and Particular Highlights Regarding Certain Antimicrobials

- **"Reduced susceptibility":** Reduced susceptibility to ciprofloxacin[1] is highlighted in this report. It was defined as a minimal concentration (MIC)[2] from 0.125 to 2 µg/mL for *Salmonella and E. coli*.
- **"Non-susceptible":** For daptomycin and florfenicol, the term "non-susceptible" is used instead of "resistant" because these antimicrobials do not have a referenced resistance breakpoint (Appendix B).
- **"Selected antimicrobials":** In the temporal variations analyses, the selected antimicrobials were chosen to represent the different antimicrobial structural classes (for the complete list of exclusion criteria, please see Appendix A). For *Salmonella* and *E. coli* isolates, selected antimicrobials included ampicillin, ceftiofur, gentamicin, nalidixic acid, streptomycin, tetracycline, and trimethoprim-sulfamethoxazole. For *Campylobacter* isolates, selected antimicrobials included azithromycin, florfenicol, gentamicin, nalidixic acid, and tetracycline. For *Enterococcus* isolates, selected antimicrobials included ciprofloxacin, erythromycin, gentamicin, quinupristin-dalfopristin, streptomycin, tetracycline, and tylosin. It should be noted that resistance to these antimicrobials does not necessarily imply equal resistance to other antimicrobials from the same class.
- Resistance to nalidixic acid (a quinolone) is highlighted for *Salmonella and E. coli*. Additionally, we have highlighted isolates with reduced susceptibility or resistance to ciprofloxacin (a fluoroquinolone) but no resistance to nalidixic acid.[3] These latter isolates may have different genetic determinants of resistance than isolates with both nalidixic acid resistance and reduced susceptibility or resistance to ciprofloxacin.
- Joint reduced susceptibility to ciprofloxacin (or resistance to nalidixic acid) and resistance to ceftriaxone, a third generation cephalosporin, is also highlighted for *Salmonella* or *E. coli*.

Additional Notes

- Temporal variations: In general, temporal variations in the percentage of isolates resistant to selected antimicrobials were identified by comparing results for 2008 with those for 2003 (the year most surveillance components of CIPARS began) and those for the previous year (2007). For data regarding retail surveillance in Saskatchewan, 2005 was the first year of surveillance.
- For data on ceftiofur and ampicillin resistance in *S.* Heidelberg and *E. coli* isolates obtained from chicken (abattoir and retail) and *S.* Heidelberg isolates from humans, the years of comparison were 2004 and 2006 because of changes in ceftiofur use in early 2005[4] and in 2007 in chicken hatcheries in Québec. For retail chicken, comparisons using those reference years were limited to the provinces of Ontario and Québec.
- Temporal variations in *Surveillance of Animal Clinical Isolates* and *Feed and Feed Ingredients* data were not tested because the intensity of passive surveillance was unequal across years.
- In the statistical analyses of temporal variations in the percentages of isolates resistant to selected antimicrobials and of differences among provinces, a value of $P \leq 0.05$ was used to indicate a significant difference between years and among provinces.

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1 The current CLSI resistance breakpoint for this antimicrobial and the one adopted in this report is ≥ 4 µg/mL. However, the Danish Integrated Antimicrobial Resistance Monitoring and Research Program (DANMAP) has used a resistance breakpoint of ≥ 0.125 µg/mL for both *Salmonella* spp. and indicator *E. coli* since 2004 and for pathogenic *E. coli* since 2006. The DANMAP also introduced European Committee on Antimicrobial Susceptibility Testing epidemiological cutoff values in their 2007 report. Because of the clinical importance of ciprofloxacin and a desire to present results in a format comparable with those of DANMAP, the term "reduced susceptibility" is used for ciprofloxacin MICs from 0.125 to 2 µg/mL. To obtain resistance estimates comparable to those from DANMAP, the percentage of *E. coli* and *Salmonella* isolates in this report with reduced susceptibility must be added to the percentage of isolates resistant to ciprofloxacin.

2 The MIC is the lowest concentration of an antimicrobial that inhibits visible bacterial growth after incubation.

3 "Fluoroquinolone-susceptible strains of *Salmonella* that test resistant to nalidixic acid may be associated with clinical failure or delayed response in fluoroquinolone-treated patients with extra-intestinal salmonellosis. Extra-intestinal isolates of *Salmonella* should also be tested for resistance to nalidixic acid. For isolates that test susceptible to fluoroquinolones and resistant to nalidixic acid, the physician should be informed that the isolate may not be eradicated by fluoroquinolone treatment." (CLSI M100-S16).

4 Public Health Agency of Canada. *Salmonella* Heidelburg Ceftiofur-Related Resistance in Human and Retail Chicken Isolates. Available at: www.phac-aspc.gc.ca/cipars-picra/heidelberg/heidelberg-eng.php. Accessed October 2010.

- With the exception of *Enterococcus faecalis* and *E. faecium*, no attempt was made to identify the species of *Enterococcus* recovered from CIPARS samples. Unidentified species of enterococci are collectively referred to in this report as "other *Enterococcus* spp." However, when used alone, the term "*Enterococcus*" refers to all enterococci, including *E. faecalis* and *E. faecium*. Similarly, *Campylobacter coli* and *C. jejuni* were the only species of *Campylobacter* that were specifically identified; unidentified species are collectively referred to as "other *Campylobacter* spp." When used alone, the term "*Campylobacter*" refers to all species of *Campylobacter*, including *C. coli* and *C. jejuni*.
- Antimicrobial abbreviations used in this report are defined in Appendix D.

Humans

Salmonella

Throughout 2008, the Provincial Public Health Laboratories forwarded a total of 3,609 *Salmonella* isolates (170 serovars) to the National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, Manitoba for phage typing, serotyping, and antimicrobial susceptibility testing (see Appendix A – Methods, Antimicrobial Resistance). No *Salmonella* isolates were identified as having been submitted by the territories (Yukon, Northwest Territories, or Nunavut) to CIPARS in 2008, directly or through Public Health Laboratories. There were duplicate submissions or records for 8 isolates; consequently, final analysis was conducted on 3,601 isolates.

Summary results are provided for the 3 most commonly isolated *Salmonella* serovars in Canada (Enteritidis, Heidelberg, and Typhimurium). *Salmonella* Newport also receives attention because of past outbreaks involving multidrug-resistant strains. Although the agri-food sector is not a source of *Salmonella* Typhi, *S.* Paratyphi A, or *S.* Paratyphi B,[1] data for these serovars are also presented because they each cause severe disease in humans.[2]

Antimicrobial resistance results are presented by province because of differences in isolate submission protocols between more populated and less populated provinces (Appendix A – Methods). Results are also presented by province because of variation among provinces in antimicrobial use and in prevailing strains and antimicrobial resistance patterns of *Salmonella*.

Because isolation of *Salmonella* from blood or urine specimens suggests patients had an invasive infection that was likely treated with antimicrobials, particular attention was paid to isolates from these specimen sources. Such specimens may have been submitted because of treatment failure, which could not be verified because patient records were not available. Therefore, isolates recovered from these specimens were potentially more likely to be resistant to multiple antimicrobials than isolates from other types of specimens.

Compared with percentages in other age groups, the greatest percentage of *Salmonella* isolates was from human patients aged 30 to 49 years (25%, 654/2,594; Table C.1, Appendix C). Ontario was the province from which the largest percentage of isolates was received (37%, 1,337/3,601).

Salmonella Enteritidis

(n = 1,258)

Provincial incidence rates for *Salmonella* Enteritidis detection in humans varied from 4.37 to 10.06 (median = 6.60) cases per 100,000 inhabitant-years (see Appendix A for formula). The most common phage types (PTs) were PT 8 (35%, 444/1,258) and PT 13 (17%, 208/1,258). Three percent (33/1,258) of isolates were recovered from blood, and 2% (21/1,258) were recovered from urine (Table C.2, Appendix C).

Antimicrobial Resistance: Results are presented in Table 1 and Table B.1, Appendix B. Less than 1% (3/1,258) of the *S.* Enteritidis isolates were resistant to amoxicillin-clavulanic acid. Resistance to ceftiofur and resistance to ceftriaxone were each detected in less than 1% (2/1,258). Reduced susceptibility to ciprofloxacin was detected in 14% (171/1,258) of the isolates. Resistance to nalidixic acid was detected in 13% (158/1,258). None of the isolates were resistant to ciprofloxacin or amikacin.

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[1] Does not include *S.* Paratyphi B var. L (+) tartrate+, formerly called *S.* Paratyphi var. Java. The biotype of *S.* Paratyphi B included here is tartrate (-) and is associated with more severe, typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate+ is commonly associated with gastroenteritis. Because animals can be a source of this serovar, it is included under "Other Serovars."

[2] Public Health Agency of Canada, *Salmonella paratyphi* Material Safety Data Sheet. Available at: www.phac-aspc.gc.ca/msds-ftss/msds133e-eng.php. Accessed November 2010.

Antimicrobial Resistance Patterns: Results are presented in Table 8 and Tables C.3 and C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 14% (182/1,258) of *S.* Enteritidis isolates. Resistance to 5 or more antimicrobials was detected in 1% (7/1,258). The most common resistance pattern was NAL (11%, 136/1,258), and 59% (80/136) of the associated isolates were PT 1. One percent (14/1,258) of isolates (PT 5b and PT 4) had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. The patterns involving the greatest number of antimicrobials among isolates were A2C-AMP-CRO-STR-TET and AKSSuT-GEN-NAL (1 PT 6a each).

Twenty-seven percent (9/33) of blood isolates and 24% (5/21) of urine isolates were resistant to 1 or more antimicrobials. The most common resistance pattern was NAL, which was found in 12% (4/33) of blood and 19% (4/21) of urine isolates.

Temporal Variations: Results are presented in Figure 2. The percentage of *S.* Enteritidis isolates with resistance to nalidixic acid was significantly lower in 2008 (13%, 158/1,258) than in 2003 (19%, 66/352). The percentage of isolates with resistance to nalidixic acid in 2008 was also significantly lower than in 2007 (18%, 167/910). The percentage of isolates with resistance to trimethoprim-sulfamethoxazole was significantly lower in 2008 (less than 1%, 5/1,258) than in 2003 (1%, 5/352). The percentage of isolates with resistance to tetracycline was significantly lower in 2008 (2%, 20/1,258) than in 2007 (6%, 58/910). Between 2008 and 2003 and between 2008 and 2007, there were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, the percentage of human *Salmonella* Enteritidis isolates with resistance to nalidixic acid (13%, 158/1,258) was significantly lower than in 2003 (19%, 66/352). The percentage of *S.* Enteritidis isolates with resistance to nalidixic acid was also significantly lower in 2008 than in 2007 (18%, 167/910). One percent (14/1,258) of isolates (PT 5b and PT 4) had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid.

TABLE 1. Resistance to antimicrobials in *Salmonella* Enteritidis isolates; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
		n = 211	n = 147	n = 58	n = 85	n = 412	n = 221	n = 39	n = 41	n = 10	n = 34	%
I	Amoxicillin-clavulanic acid	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
	Ceftiofur	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
	Ceftriaxone	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	Ampicillin	11 (5)	4 (3)	1 (2)	0 (0)	11 (3)	5 (2)	0 (0)	1 (2)	0 (0)	0 (0)	3
	Cefoxitin	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
	Gentamicin	0 (0)	1 (1)	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
	Kanamycin	0 (0)	1 (1)	0 (0)	0 (0)	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
	Nalidixic acid	23 (11)	22 (15)	8 (14)	12 (14)	56 (14)	25 (11)	6 (15)	4 (10)	0 (0)	2 (6)	13
	Streptomycin	3 (1)	1 (1)	0 (0)	0 (0)	5 (1)	1 (0)	0 (0)	1 (2)	0 (0)	0 (0)	< 1
	Trimethoprim-sulfamethoxazole	0 (0)	1 (1)	0 (0)	0 (0)	1 (0)	2 (1)	1 (3)	0 (0)	0 (0)	0 (0)	< 1
III	Chloramphenicol	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
	Sulfisoxazole	2 (1)	2 (1)	0 (0)	0 (0)	4 (1)	2 (1)	1 (3)	1 (2)	0 (0)	0 (0)	< 1
	Tetracycline	3 (1)	5 (3)	0 (0)	0 (0)	6 (1)	3 (1)	1 (3)	1 (2)	0 (0)	1 (3)	2
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces, whereas percentages in the text represent crude estimates (see Appendix A).

Salmonella Heidelberg

(n = 290)

Provincial incidence rates for *Salmonella* Heidelberg detection in humans varied from 0.70 to 3.62 (median = 1.67) cases per 100,000 inhabitant-years. The most common phage types were PT 19 (54%, 157/290), PT 29 (8%, 24/290), and PT 5 (8%, 22/290). Twelve percent (34/290) of isolates were cultured from blood, and 2% (6/290) were cultured from urine (Table C.2, Appendix C).

Antimicrobial Resistance: Results are presented in Table 2 and Table B.2, Appendix B. Resistance to amoxicillin-clavulanic acid was detected in 13% (39/290) of *S.* Heidelberg isolates. Resistance to ceftiofur and ceftriaxone were each detected in 14% (41/290) of isolates. No isolates were resistant to ciprofloxacin, amikacin, or nalidixic acid. None had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 8 and Tables C.3 and C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 38% (111/290) of *S.* Heidelberg isolates. Resistance to 5 or more antimicrobials was detected in 14% (41/290). The most common resistance pattern was AMP (14%, 42/290). This resistance pattern was mainly detected among PT 19 isolates (93%, 39/42) and most of those isolates were from Ontario (46%, 18/39) and Québec (41%, 16/39). The pattern involving the greatest number of antimicrobials among isolates was ACKSSuT-A2C-CRO-SXT (1 PT 21).

Forty-four percent (15/34) of blood isolates and 2 of 6 urine isolates were resistant to 1 or more antimicrobials. The most common resistance pattern, AMP, was detected in 18% (6/34) of blood isolates (PT 19) and in no urine isolates.

Temporal Variations: Results are presented in Figure 2. The percentage of *S.* Heidelberg isolates with resistance to ceftiofur was significantly lower in 2008 (14%) than in 2004 (33%, 181/556).[1] Similarly, the percentage of isolates with resistance to ampicillin was significantly lower in 2008 (32%, 92/290) than in 2006 (39%, 168/430) and 2004 (45%, 250/556). The percentages of isolates with resistance to streptomycin and tetracycline were significantly lower in 2008 (7% [20/290] and 6% [18/290], respectively) than in 2003 (12% [72/608] and 15% [93/608], respectively). Between 2008 and 2003 and between 2008 and 2007, there were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, the percentage of human *Salmonella* Heidelberg isolates with resistance to ceftiofur (14%, 41/290) was significantly lower than in 2004 (33%, 181/556).

[1] 2004 and 2006 were selected as years of comparison for ceftiofur and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005 and in 2006 (start and end of the voluntary period of withdrawal).

TABLE 2. Resistance to antimicrobials in *Salmonella* Heidelberg isolates; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
		n = 16	n = 32	n = 7	n = 19	n = 102	n = 65	n = 17	n = 22	n = 5	n = 5	%
I	Amoxicillin-clavulanic acid	2 (13)	7 (22)	0 (0)	2 (11)	14 (14)	8 (12)	4 (24)	1 (5)	0 (0)	1 (20)	14
	Ceftiofur	3 (19)	8 (25)	0 (0)	2 (11)	14 (14)	8 (12)	4 (24)	1 (5)	0 (0)	1 (20)	15
	Ceftriaxone	3 (19)	8 (25)	0 (0)	2 (11)	14 (14)	8 (12)	4 (24)	1 (5)	0 (0)	1 (20)	15
	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	Ampicillin	5 (31)	11 (34)	0 (0)	3 (16)	36 (35)	28 (43)	6 (35)	2 (9)	0 (0)	1 (20)	34
	Cefoxitin	2 (13)	7 (22)	0 (0)	2 (11)	14 (14)	8 (12)	3 (18)	1 (5)	0 (0)	1 (20)	14
	Gentamicin	0 (0)	0 (0)	0 (0)	1 (5)	1 (1)	3 (5)	1 (6)	0 (0)	0 (0)	1 (20)	2
	Kanamycin	1 (6)	2 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
	Nalidixic acid	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	Streptomycin	0 (0)	5 (16)	0 (0)	1 (5)	7 (7)	6 (9)	1 (6)	0 (0)	0 (0)	0 (0)	8
	Trimethoprim-sulfamethoxazole	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)	2 (3)	0 (0)	1 (5)	0 (0)	0 (0)	1
III	Chloramphenicol	0 (0)	1 (3)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
	Sulfisoxazole	0 (0)	1 (3)	0 (0)	1 (5)	2 (2)	5 (8)	1 (6)	1 (5)	0 (0)	0 (0)	4
	Tetracycline	2 (13)	6 (19)	0 (0)	1 (5)	4 (4)	2 (3)	1 (6)	1 (5)	1 (20)	0 (0)	6
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces, whereas percentages in the text represent crude estimates (see Appendix A).

Salmonella Newport

(n = 177)

Provincial incidence rates for *Salmonella* Newport detection in humans varied from 0 to 1.69 (median = 0.66) cases per 100,000 inhabitant-years. There were no reported cases in Prince Edward Island. The most common phage types recovered from samples were PT 9 (22%, 39/177) and phage types designated as atypical (16%, 29/177). Six percent (11/177) of the isolates were cultured from urine, and 4% (7/177) were cultured from blood (Table C.2, Appendix C).

Antimicrobial Resistance: Results are presented in Table 3 and Table B.3, Appendix B. Resistance to amoxicillin-clavulanic acid was detected in 1% (2/177) of *S.* Newport isolates, and ceftiofur and ceftriaxone resistance were each detected in 2% (3/177). Reduced susceptibility to ciprofloxacin and resistance to nalidixic acid were each detected in 1% (2/177) of isolates. None of the isolates were resistant to ciprofloxacin or amikacin.

Antimicrobial Resistance Patterns: Results are presented in Table 8 and Tables C.3 and C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 5% (9/177) of *S.* Newport isolates. Resistance to 5 or more antimicrobials was detected in 2% (4/177). The most common resistance patterns were TET (1%, 2/177), which was detected in 1 PT 9 and 1 PT 14c isolate, and ACSSuT-A2C-CRO (1%, 2/177), which was detected in 1 PT 17a and 1 PT 17c isolate. The pattern involving the greatest number of antimicrobials among isolates was ACSSuT-A2C-CRO (1 PT 17a and 1 PT 17c), which was also among the most common resistance patterns. None of the isolates from blood or urine were resistant to 1 or more antimicrobials.

Temporal Variations: Results are presented in Figure 2. The percentages of *S.* Newport isolates with resistance to ceftiofur or ampicillin were significantly lower in 2008 (2% and 3% [5/177], respectively) than in 2003 (10% [17/175] and 13% [22/175], respectively). The percentages of isolates with resistance to streptomycin and tetracycline were also significantly lower in 2008 (2% [4/177] and 4% [7/177], respectively) than in 2003 (10% [17/175] and 13% [22/175], respectively). Between 2008 and 2003 and between 2008 and 2007, there were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, the percentages of human *Salmonella* Newport isolates with resistance to ceftiofur and ampicillin (2%, [3/177] and 3% [5/177], respectively) were significantly lower than in 2003 (10% [17/175] and 13% [22/175], respectively). The percentages of isolates with resistance to streptomycin and tetracycline were also significantly lower in 2008 (2% [4/177] and 4% [7/177], respectively) than in 2003 (10% [17/175] and 13% [22/175], respectively).

TABLE 3. Resistance to antimicrobials in *Salmonella* Newport isolates; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	Number (%) of isolates resistant										Canada
		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
		n = 18	n = 28	n = 8	n = 6	n = 74	n = 37	n = 3	n = 2	n = 0	n = 1	%
I	Amoxicillin-clavulanic acid	0 (0)	1 (4)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)		0 (0)	1
	Ceftiofur	0 (0)	2 (7)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)		0 (0)	2
	Ceftriaxone	0 (0)	2 (7)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)		0 (0)	2
	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0
	Ampicillin	0 (0)	3 (11)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)		0 (0)	3
	Cefoxitin	0 (0)	1 (4)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)		0 (0)	1
	Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)		0 (0)	< 1
	Kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)		0 (0)	< 1
	Nalidixic acid	0 (0)	0 (0)	1 (13)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)		0 (0)	< 1
	Streptomycin	0 (0)	2 (7)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)		0 (0)	2
	Trimethoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)		0 (0)	1
III	Chloramphenicol	0 (0)	2 (7)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)		0 (0)	2
	Sulfisoxazole	0 (0)	2 (7)	0 (0)	0 (0)	3 (4)	0 (0)	0 (0)	0 (0)		0 (0)	3
	Tetracycline	0 (0)	3 (11)	0 (0)	0 (0)	4 (5)	0 (0)	0 (0)	0 (0)		0 (0)	4
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

No *S.* Newport isolates were received from Prince Edward Island.

Salmonella Paratyphi A and Paratyphi B

(n = 65)

The combined provincial incidence rates for *Salmonella* Paratyphi A and *Salmonella* Paratyphi B[1] detection varied from 0 to 0.91 (median = 0.18) cases per 100,000 inhabitant-years. No cases were reported in New Brunswick, Prince Edward Island, or Newfoundland and Labrador. Phage typing is not applicable to *S.* Paratyphi A isolates. Among the 12 isolates of *S.* Paratyphi B, phage types included atypical (9/12), Battersea (2/12), and Worksop (1/12). Sixty-four percent (34/53) of *S.* Paratyphi A isolates were cultured from blood, and 2% (1/53) were cultured from urine. One of the 12 *S.* Paratyphi B isolates was cultured from blood, and no such isolates were cultured from urine (Table C.2, Appendix C).

Antimicrobial Resistance: Results are presented in Table 4 and Table B.4, Appendix B. Resistance to amoxicillin-clavulanic acid was detected in 4% (2/53) of *S.* Paratyphi A isolates. Ceftiofur and ceftriaxone resistance were each detected in 2% (1/53) of *S.* Paratyphi A isolates. Reduced susceptibility to ciprofloxacin and resistance to nalidixic acid were each detected in 89% (47/53) of *S.* Paratyphi A isolates. None of the *S.* Paratyphi A or *S.* Paratyphi B isolates were resistant to ciprofloxacin or amikacin. None of the *S.* Paratyphi B isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, cefoxitin, gentamicin, kanamycin, nalidixic acid, or trimethoprim-sulfamethoxazole or had reduced susceptibility to ciprofloxacin.

[1] Does not include *S.* Paratyphi B var. L (+) tartrate+, formerly called *S.* Paratyphi var. Java. The biotype of *S.* Paratyphi B included here is tartrate (-) and is associated with more severe, typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate+ is commonly associated with gastroenteritis. Because animals can be a source of this serovar, it is included under "Other Serovars."

Antimicrobial Resistance Patterns: Results are presented in Table 8 and Tables C.3 and C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 91% (48/53) of *S.* Paratyphi A isolates and in 2 of 12 *S.* Paratyphi B isolates. Resistance to 5 or more antimicrobials was detected in 4% (2/53) of *S.* Paratyphi A isolates and in 1 of 12 *S.* Paratyphi B isolates. The most common resistance pattern among *S.* Paratyphi A isolates was NAL (87%, 46/53). Of those isolates, 46% (21/46) were from Ontario and 37% (17/46) were from British Columbia (no phage type information available). The pattern involving the greatest number of antimicrobials among *S.* Paratyphi A isolates was ACKSSuT-A2C-CRO-GEN (no phage type information available) and among *S.* Paratyphi B isolates was ACSSuT (1 atypical phage type).

Among blood isolates, the most common resistance pattern was NAL (89%, 31/35), and all isolates having this pattern were *S.* Paratyphi A. The 1 *S.* Paratyphi A urine isolate was also resistant to nalidixic acid.

Temporal Variations: Results are presented in Figure 3. Between 2008 and 2003 and between 2008 and 2007, there were no significant temporal variations in the percentages of *S.* Paratyphi A or *S.* Paratyphi B isolates resistant to the selected antimicrobials.

In 2008, the most common resistance pattern among human *Salmonella* Paratyphi A isolates was NAL (87%, 46/53). Of those isolates, 46% (21/46) were from Ontario and 37% (17/46) were from British Columbia.

TABLE 4. Resistance to antimicrobials in *Salmonella* Paratyphi A and *S.* Paratyphi B isolates; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
		n = 19	n = 4	n = 1	n = 5	n = 24	n = 11	n = 0	n = 1	n = 0	n = 0	%
I	Amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	1 (20)	1 (4)	0 (0)		0 (0)			2
	Ceftiofur	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	0 (0)		0 (0)			< 1
	Ceftriaxone	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	0 (0)		0 (0)			< 1
	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)			0
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)			0
	Ampicillin	0 (0)	0 (0)	0 (0)	1 (20)	1 (4)	0 (0)		1 (100)			3
	Cefoxitin	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	0 (0)		0 (0)			< 1
	Gentamicin	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	0 (0)		0 (0)			< 1
	Kanamycin	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	0 (0)		0 (0)			< 1
	Nalidixic acid	17 (89)	3 (75)	0 (0)	3 (60)	22 (92)	2 (18)		0 (0)			74
	Streptomycin	0 (0)	0 (0)	0 (0)	1 (20)	1 (4)	0 (0)		1 (100)			3
	Trimethoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)	0 (0)	1 (4)	0 (0)		0 (0)			2
III	Chloramphenicol	0 (0)	0 (0)	0 (0)	1 (20)	1 (4)	0 (0)		1 (100)			3
	Sulfisoxazole	0 (0)	0 (0)	0 (0)	1 (20)	1 (4)	0 (0)		1 (100)			3
	Tetracycline	0 (0)	0 (0)	0 (0)	1 (20)	1 (4)	1 (9)		1 (100)			5
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

No *S.* Paratyphi A or *S.* Paratyphi B isolates were received from New Brunswick, Prince Edward Island, or Newfoundland and Labrador.

[a] Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces, whereas percentages in the text represent crude estimates (see Appendix A).

Salmonella Typhi

(n = 186)

Provincial incidence rates for *Salmonella* Typhi detection in humans varied from 0 to 2.34 cases (median = 0.22) per 100,000 inhabitant-years. No cases were reported in New Brunswick, Nova Scotia, Prince Edward Island, or Newfoundland and Labrador. The most common phage types recovered were PT E1 (35%, 65/186), PT UVS (I + IV) (11%, 20/186), PT UVS (10%, 19/186), and PT G3 (10%, 18/186). The phage type could not be identified and was designated as atypical in 8% (15/186) of isolates. Seventy-five percent (140/186) of isolates were cultured from blood, and less than 1% (1/186) were cultured from urine (Table C.2, Appendix C).

Antimicrobial Resistance: Results are presented in Table 5 and Table B.5, Appendix B. Reduced susceptibility to ciprofloxacin was detected in 72% (134/186) of *S.* Typhi isolates. Resistance to nalidixic acid was detected in 69% (129/186). None of the isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, or gentamicin.

Antimicrobial Resistance Patterns: Results are presented in Table 8 and Tables C.3 and C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 74% (137/186) of *S.* Typhi isolates. Resistance to 5 or more antimicrobials was detected in 17% (31/186). The most common resistance pattern was NAL (54%, 100/186). This resistance pattern was mainly detected among PT E1 (47%, 47/100), PT UVS (I + IV) (14%, 14/100), and PT G3 (10%, 10/100) isolates. Fifty percent (50/100) of the isolates that had the NAL resistance pattern were from Ontario. Three percent (6/186) of isolates had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. The pattern involving the greatest number of antimicrobials was ACSSuT-NAL-SXT (3 untypable, 1 PT E1, and 1 PT UVS [I + IV]).

Among blood isolates, the most common resistance pattern was NAL, which was detected in 54% (76/140) of isolates. Common phage types associated with this resistance pattern included PT E1 (45%, 34/76) and PT UVS (I + IV) (13%, 10/76). The 1 urine isolate (PT G3) also had the NAL resistance pattern.

Temporal Variations: Results are presented in Figure 3. The percentage of *S.* Typhi isolates with resistance to nalidixic acid was significantly higher in 2008 (69%) than in 2003 (44%, 56/127) but was similar between 2008 and 2007 (78%, 122/156). The percentage of *S.* Typhi isolates with resistance to tetracycline was significantly lower in 2008 (6%, 11/186) than in 2007 (13%, 20/156). Between 2008 and 2003 and between 2008 and 2007, there were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, reduced susceptibility to ciprofloxacin was detected in 72% (134/186) of human *Salmonella* Typhi isolates and resistance to nalidixic acid was detected in 69% (129/186) of isolates. The percentage of isolates that were resistant to nalidixic acid was significantly higher in 2008 (69%, 129/186) than in 2003 (44%, 56/127) but was similar between 2008 and 2007 (78%, 122/156). Three percent (6/186) of the isolates had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid.

TABLE 5. Resistance to antimicrobials in *Salmonella* Typhi isolates; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	Number (%) of isolates resistant										Canada
		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
		n = 49	n = 17	n = 1	n = 4	n = 97	n = 18	n = 0	n = 0	n = 0	n = 0	%
I	Amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
	Ceftiofur	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
	Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
	Ampicillin	2 (4)	4 (24)	1 (100)	0 (0)	18 (19)	6 (33)					17
	Cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
	Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
	Kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (6)					< 1
	Nalidixic acid	34 (69)	14 (82)	1 (100)	3 (75)	67 (69)	10 (56)					69
	Streptomycin	2 (4)	4 (24)	1 (100)	0 (0)	20 (21)	6 (33)					18
	Trimethoprim-sulfamethoxazole	2 (4)	3 (18)	1 (100)	0 (0)	20 (21)	6 (33)					17
III	Chloramphenicol	2 (4)	3 (18)	1 (100)	0 (0)	21 (22)	6 (33)					18
	Sulfisoxazole	2 (4)	4 (24)	1 (100)	0 (0)	21 (22)	6 (33)					18
	Tetracycline	2 (4)	3 (18)	1 (100)	0 (0)	4 (4)	1 (6)					6
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

No *S.* Typhi isolates were received from New Brunswick, Nova Scotia, Prince Edward Island, or Newfoundland and Labrador.

Salmonella Typhimurium

(n = 474)

Provincial incidence rates for *Salmonella* Typhimurium detection in humans varied from 1.17 to 3.49 (median = 2.18) cases per 100,000 inhabitant-years. The most common phage types recovered were PT 108 (21%, 99/474), PT atypical (14%, 68/474), PT 104 (11%, 52/474), and PT 104b (6%, 29/474). Three percent (16/474) of isolates were cultured from blood, and 2% (11/474) were cultured from urine (Table C.2, Appendix C).

Antimicrobial Resistance: Results are presented in Table 6 and Table B.6, Appendix B. Resistance to amoxicillin-clavulanic acid was detected in 2% (12/474) of *S.* Typhimurium isolates. Resistance to ceftiofur and ceftriaxone were each detected in 2% (11/474). Three percent (15/474) of the isolates had reduced susceptibility to ciprofloxacin. Resistance to nalidixic acid was detected in 2% (10/474) of isolates. None of the isolates were resistant to ciprofloxacin or amikacin.

Antimicrobial Resistance Patterns: Results are presented in Table 8 and Tables C.3 and C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 40% (187/474) of *S.* Typhimurium isolates. Resistance to 5 or more antimicrobials was detected in 25% (118/474). The most common resistance pattern was ACSSuT (14%, 64/474), and most isolates with this pattern were PT 104 (55%, 35/64) and PT 104b (28%, 18/64). One isolate designated as an untypable phage type had reduced susceptibility to ciprofloxacin and resistance to ceftriaxone. One percent (5/474) of isolates had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. The patterns involving the greatest number of antimicrobials among isolates were ACSSuT-A2C-CRO-GEN (1 PT U302 and 1 untypable phage type), ACSSuT-A2C-CRO-SXT (1 PT U302), ACSSuT-A2C-CRO (2 PT 99 and 1 PT U302), and ACKSSuT-GEN-NAL-SXT (1 PT 120).

Ten of the 16 blood isolates and 7 of the 11 urine isolates were resistant to 1 or more antimicrobials. The most common resistance pattern among blood isolates was ACSSuT (6/16) and among urine isolates was AMP-SSS-TET (2/11).

Temporal Variations: Results are presented in Figure 3. The percentages of *S.* Typhimurium isolates with resistance to ampicillin, streptomycin, and tetracycline were significantly lower in 2008 (31% [145/474], 30% [144/474], and 32% [152/474], respectively) than in 2003 (44% [269/605], 39% [234/605)], and 47% [282/605], respectively). However, percentages of isolates with resistance to ampicillin and streptomycin were significantly higher in 2008 (31% and 30%, respectively) than in 2007 (22% [145/658] and 23% [149/658], respectively). The percentage of isolates with resistance to tetracycline remained similar between 2008 (32%) and 2007 (27%, 176/658). Between 2008 and 2003 and between 2008 and 2007, there were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, the percentages of human *Salmonella* Typhimurium isolates with resistance to ampicillin and streptomycin (31% [145/474] and 30% [144/474], respectively) were significantly higher than in 2007 (22% [145/658] and 23% [149/658], respectively).

TABLE 6. Resistance to antimicrobials in *Salmonella* Typhimurium isolates; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
		n = 37	n = 58	n = 33	n = 26	n = 211	n = 62	n = 16	n = 23	n = 2	n = 6	%
I	Amoxicillin-clavulanic acid	1 (3)	0 (0)	1 (3)	3 (12)	6 (3)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	2
	Ceftiofur	1 (3)	0 (0)	1 (3)	4 (15)	4 (2)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	2
	Ceftriaxone	1 (3)	0 (0)	1 (3)	4 (15)	4 (2)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	2
	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	Ampicillin	15 (41)	14 (24)	12 (36)	11 (42)	63 (30)	23 (37)	5 (31)	2 (9)	0 (0)	0 (0)	31
	Cefoxitin	1 (3)	1 (2)	1 (3)	3 (12)	4 (2)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	2
	Gentamicin	2 (5)	2 (3)	1 (3)	1 (4)	5 (2)	0 (0)	1 (6)	0 (0)	0 (0)	0 (0)	2
	Kanamycin	9 (24)	13 (22)	2 (6)	3 (12)	18 (9)	8 (13)	4 (25)	1 (4)	0 (0)	1 (17)	13
	Nalidixic acid	2 (5)	3 (5)	0 (0)	1 (4)	2 (1)	1 (2)	1 (6)	0 (0)	0 (0)	0 (0)	2
	Streptomycin	14 (38)	21 (36)	13 (39)	9 (35)	65 (31)	18 (29)	4 (25)	0 (0)	0 (0)	0 (0)	31
	Trimethoprim-sulfamethoxazole	5 (14)	2 (3)	0 (0)	2 (8)	7 (3)	5 (8)	2 (13)	1 (4)	0 (0)	0 (0)	5
III	Chloramphenicol	9 (24)	8 (14)	11 (33)	3 (12)	54 (26)	13 (21)	2 (13)	0 (0)	0 (0)	0 (0)	22
	Sulfisoxazole	17 (46)	22 (38)	13 (39)	9 (35)	67 (32)	19 (31)	6 (38)	3 (13)	0 (0)	0 (0)	33
	Tetracycline	19 (51)	13 (22)	14 (42)	8 (31)	63 (30)	24 (39)	6 (38)	3 (13)	0 (0)	2 (33)	32
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces, whereas percentages in the text represent crude estimates (see Appendix A).

Salmonella "Other Serovars"

(n = 1,151)

The *Salmonella* "Other Serovars" represented 32% (1,151/3,601) of all S*almonella* isolates and included 162 different serovars. Four percent (49/1,151) of the isolates were cultured from blood, and 7% (78/1,151) were cultured from urine (Table C.2, Appendix C).

Antimicrobial Resistance: Results are presented in Table 7 and Table B.7, Appendix B. Resistance to amoxicillin-clavulanic acid was detected in 2% (19/1,151) of *Salmonella* "Other Serovars" isolates (Agona, Anatum, ssp. I 4,[5],12:i:-, ssp. I Rough-O:i:-, ssp. I Rough-O:i:1,2, ssp. Rough-O:r:1,2, Kentucky, Reading, Saintpaul, and Stanley). Resistance to ceftiofur and ceftriaxone were each detected in 2% (21/1,151) of isolates (ssp. I 4,[5],12:i:-, Agona, Anatum, Hadar, ssp. I Rough-O:i:1,2, ssp. Rough-O:r:1,2, Irenea, Kentucky, Reading, Saintpaul, and Stanley). One percent (11/1,151) of isolates (Kentucky) were resistant to ciprofloxacin, and 5% (60/1,151) had reduced susceptibility to ciprofloxacin and were mainly ssp. I 4,[5],12:i:-, Infantis, Hadar, Agona, Thompson, and ssp. I 4,[5],12:b:-. Resistance to nalidixic acid was detected in 5% (56/1,151). None of the isolates were resistant to amikacin.

Antimicrobial Resistance Patterns: Results are presented in Table 8 and Tables C.3 and C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 24% (274/1,151) of *Salmonella* "Other Serovars" isolates. Most of these isolates included serovars Hadar (22%. 60/274), ssp. I 4,[5],12:i:- (18%, 48/274), Agona (7%, 18/274), and Kentucky (7%, 18/274). Resistance to 5 or more antimicrobials was detected in 5% (60/1,151) of isolates. The most common resistance pattern was STR-TET (5%, 55/1,151), which was detected primarily in Hadar (82%, 45/55) and Kentucky (11%, 6/55) isolates. Less than 1% (2/1,151) of isolates (Saintpaul and ssp. I 4,[5],12:i:-) had reduced susceptibility to ciprofloxacin and resistance to ceftriaxone. Two percent (18/1,151) of the isolates (Corvallis, Derby, ssp. I 4,[5],12:i:-, ssp. I Rough-O:i:-, Litchfield, Manhattan, Mbandaka, Muenster, Saintpaul, and Weltevreden) had reduced susceptibility to ciprofloxacin and were not resistant to nalidixic acid. The pattern involving the greatest number of antimicrobials among isolates was ACKSSuT-A2C-CRO-GEN-SXT (1 Saintpaul).

Twenty-two percent (11/49) of blood isolates and 20% (14/78) of urine isolates were resistant to 1 or more antimicrobials. The most common resistance patterns among blood isolates were NAL (4% 2/49) and STR-TET (4%, 2/49) and among urine isolates were SSS-TET (4%, 3/78) and STR-TET (4%, 3/78).

Temporal Variations: Results are presented in Figure 3. Between 2008 and 2003, no significant temporal variations were detected in the percentages of *Salmonella* "Other Serovars" isolates with resistance to the selected antimicrobials. The percentage of isolates with resistance to ceftiofur was significantly higher in 2008 (2%) than in 2007 (1%, 8/1,090). Similarly, the percentages of isolates with resistance to gentamicin and nalidixic acid were significantly higher in 2008 (2% [28/1,151] and 5%, respectively) than in 2007 (1% [6/1,090] and 3% [35/1,090)], respectively). Between 2008 and 2007, there were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, 2 of 1,151 human *Salmonella* "Other Serovars" isolates (*S.* Saintpaul and *Salmonella* ssp. I 4,[5],12:i:-) had reduced susceptibility to ciprofloxacin with resistance to ceftriaxone. Two percent (18/1,151) of isolates (*S.* Corvallis, *S.* Derby, *Salmonella* ssp. I 4,[5],12:i:-, *Salmonella* ssp. I Rough-O:i:-, *S.* Litchfield, *S.* Manhattan, *S.* Mbandaka, *S.* Muenster, *S.* Saintpaul, and *S.* Weltevreden) had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. The percentage of isolates with resistance to ceftiofur was significantly higher in 2008 (2%, 21/1,151) than in 2007 (1%, 8/1,090). Similarly, the percentages of isolates with resistance to gentamicin and nalidixic acid were significantly higher in 2008 (2% [28/1,151] and 5% [56/1,151], respectively) than in 2007 (1% [6/1,090] and 3% [35/1,090)], respectively).

TABLE 7. Resistance to antimicrobials in *Salmonella* "Other Serovars" isolates; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
		n = 157	n = 142	n = 76	n = 103	n = 417	n = 168	n = 32	n = 39	n = 5	n = 12	%
I	Amoxicillin-clavulanic acid	3 (2)	2 (1)	1 (1)	2 (2)	5 (1)	4 (2)	1 (3)	1 (3)	0 (0)	0 (0)	2
	Ceftiofur	3 (2)	2 (1)	1 (1)	2 (2)	5 (1)	4 (2)	1 (3)	2 (5)	0 (0)	1 (8)	2
	Ceftriaxone	3 (2)	2 (1)	1 (1)	2 (2)	5 (1)	4 (2)	1 (3)	2 (5)	0 (0)	1 (8)	2
	Ciprofloxacin	1 (1)	1 (1)	0 (0)	0 (0)	5 (1)	3 (2)	0 (0)	0 (0)	1 (20)	0 (0)	1
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	Ampicillin	10 (6)	9 (6)	5 (7)	7 (7)	21 (5)	13 (8)	1 (3)	5 (13)	1 (20)	1 (8)	6
	Cefoxitin	3 (2)	2 (1)	2 (3)	5 (5)	5 (1)	4 (2)	1 (3)	1 (3)	0 (0)	0 (0)	2
	Gentamicin	3 (2)	2 (1)	1 (1)	3 (3)	11 (3)	3 (2)	0 (0)	3 (8)	1 (20)	1 (8)	2
	Kanamycin	2 (1)	2 (1)	1 (1)	1 (1)	8 (2)	2 (1)	0 (0)	0 (0)	1 (20)	0 (0)	2
	Nalidixic acid	16 (10)	4 (3)	4 (5)	2 (2)	22 (5)	5 (3)	2 (6)	0 (0)	1 (20)	0 (0)	5
	Streptomycin	24 (15)	13 (9)	10 (13)	14 (14)	52 (12)	17 (10)	3 (9)	10 (26)	1 (20)	3 (25)	12
	Trimethoprim-sulfamethoxazole	10 (6)	2 (1)	5 (7)	3 (3)	17 (4)	2 (1)	1 (3)	0 (0)	0 (0)	0 (0)	3
III	Chloramphenicol	6 (4)	5 (4)	4 (5)	5 (5)	8 (2)	3 (2)	1 (3)	2 (5)	0 (0)	1 (8)	3
	Sulfisoxazole	20 (13)	13 (9)	11 (14)	14 (14)	40 (10)	14 (8)	1 (3)	6 (15)	2 (40)	2 (17)	10
	Tetracycline	38 (24)	26 (18)	27 (36)	24 (23)	65 (16)	25 (15)	4 (13)	8 (21)	2 (40)	6 (50)	19
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces, whereas percentages in the text represent crude estimates (see Appendix A).

TABLE 8. Number of antimicrobials in resistance patterns of *Salmonella* isolates from humans, by province and serovar; *Surveillance of Human Clinical Isolates*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
British Columbia					
Enteritidis	211 (41.6)	182	28	1	0
Typhi	49 (9.7)	13	34	2	0
Typhimurium	37 (7.3)	16	10	10	1
Newport	18 (3.6)	18	0	0	0
Paratyphi A	18 (3.6)	1	17	0	0
Heidelberg	16 (3.2)	10	6	0	0
I 4,[5],12:i:-	14 (2.8)	6	6	1	1
Stanley	11 (2.2)	6	4	0	1
Less common serovars	133 (26.2)	97	33	3	0
Total	507 (100)	349	138	17	3
Alberta					
Enteritidis	147 (34.3)	120	26	1	0
Typhimurium	58 (13.6)	34	12	12	0
Heidelberg	32 (7.5)	18	12	1	1
Newport	28 (6.5)	24	2	2	0
I 4,[5],12:i:-	18 (4.2)	11	7	0	0
Typhi	17 (4.0)	3	10	4	0
Infantis	14 (3.3)	14	0	0	0
Less common serovars	114 (26.6)	88	19	7	0
Total	428 (100)	312	88	27	1
Saskatchewan					
Enteritidis	58 (31.5)	50	8	0	0
Typhimurium	33 (17.9)	18	4	10	1
I 4,[5],12:i:-	18 (9.8)	11	6	0	1
Hadar	9 (4.9)	0	9	0	0
Newport	8 (4.3)	7	1	0	0
Heidelberg	7 (3.8)	7	0	0	0
Agona	6 (3.3)	1	5	0	0
Less common serovars	45 (24.5)	36	6	3	0
Total	184 (100)	130	39	13	2
Manitoba					
Enteritidis	85 (34.3)	73	12	0	0
Typhimurium	26 (10.5)	15	3	7	1
I 4,[5],12:i:-	24 (9.7)	17	7	0	0
Heidelberg	19 (7.7)	14	5	0	0
Agona	8 (3.2)	6	2	0	0
Newport	6 (2.4)	6	0	0	0
Kentucky	5 (2.0)	3	2	0	0
Thompson	5 (2.0)	5	0	0	0
Less common serovars	70 (28.2)	42	25	2	1
Total	248 (100)	181	56	9	2
Ontario					
Enteritidis	412 (30.8)	347	62	3	0
Typhimurium	211 (15.8)	136	19	54	2
Heidelberg	102 (7.6)	59	43	0	0
Typhi	97 (7.3)	25	54	18	0
Newport	74 (5.5)	70	2	1	1
Infantis	37 (2.8)	35	2	0	0
I 4,[5],12:i:-	28 (2.1)	19	8	1	0
Less common serovars	376 (28.1)	289	68	17	2
Total	1,337 (100)	980	258	94	5

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

TABLE 8 (continued). Number of antimicrobials in resistance patterns of *Salmonella* isolates from humans, by province and serovar; *Surveillance of Human Clinical Isolates*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Québec					
Enteritidis	221 (38.0)	193	28	0	0
Heidelberg	65 (11.2)	34	29	2	0
Typhimurium	62 (10.7)	33	15	13	1
Newport	37 (6.4)	37	0	0	0
Typhi	18 (3.1)	7	5	6	0
Thompson	16 (2.7)	15	1	0	0
I 4,[5],12:i:-	15 (2.6)	8	6	1	0
I 4,[5],12:b:-	12 (2.1)	12	0	0	0
Less common serovars	136 (23.4)	108	22	6	0
Total	582 (100)	447	106	28	1
New Brunswick					
Enteritidis	39 (36.4)	33	6	0	0
Heidelberg	17 (15.9)	11	5	1	0
Typhimurium	16 (15.0)	10	2	4	0
Agona	5 (4.7)	4	0	1	0
Hadar	3 (2.8)	0	3	0	0
Hartford	3 (2.8)	3	0	0	0
Newport	3 (2.8)	3	0	0	0
Oranienburg	3 (2.8)	3	0	0	0
Less common serovars	18 (16.8)	16	2	0	0
Total	107 (100)	83	18	6	0
Nova Scotia					
Enteritidis	41 (32.0)	37	3	1	0
Typhimurium	23 (18.0)	19	4	0	0
Heidelberg	22 (17.2)	19	3	0	0
Hadar	7 (5.5)	0	6	1	0
I 4,[5],12:i:-	3 (2.3)	2	1	0	0
Infantis	3 (2.3)	3	0	0	0
Poona	3 (2.3)	3	0	0	0
Less common serovars	26 (20.3)	22	1	3	0
Total	128 (100)	105	18	5	0
Prince Edward Island					
Enteritidis	10 (45.5)	10	0	0	0
Heidelberg	5 (22.7)	4	1	0	0
I 4,[5],12:b:-	2 (9.1)	2	0	0	0
Typhimurium	2 (9.1)	2	0	0	0
I 4,[5],12:i:-	1 (4.5)	0	1	0	0
Infantis	1 (4.5)	1	0	0	0
Kentucky	1 (4.5)	0	0	1	0
Total	22 (100)	19	2	1	0
Newfoundland and Labrador					
Enteritidis	34 (58.6)	31	3	0	0
Typhimurium	6 (10.3)	4	2	0	0
Heidelberg	5 (8.6)	3	2	0	0
Hadar	3 (5.2)	0	3	0	0
I 4,[5],12:i:-	3 (5.2)	2	0	1	0
Agona	2 (3.4)	0	2	0	0
Less common serovars	5 (8.6)	5	0	0	0
Total	58 (100)	45	12	1	0

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

FIGURE 2. Temporal variation in resistance to selected antimicrobials in human *Salmonella* isolates, serovars Enteritidis, Heidelberg, and Newport; *Surveillance of Human Clinical Isolates*, 2003-2008.

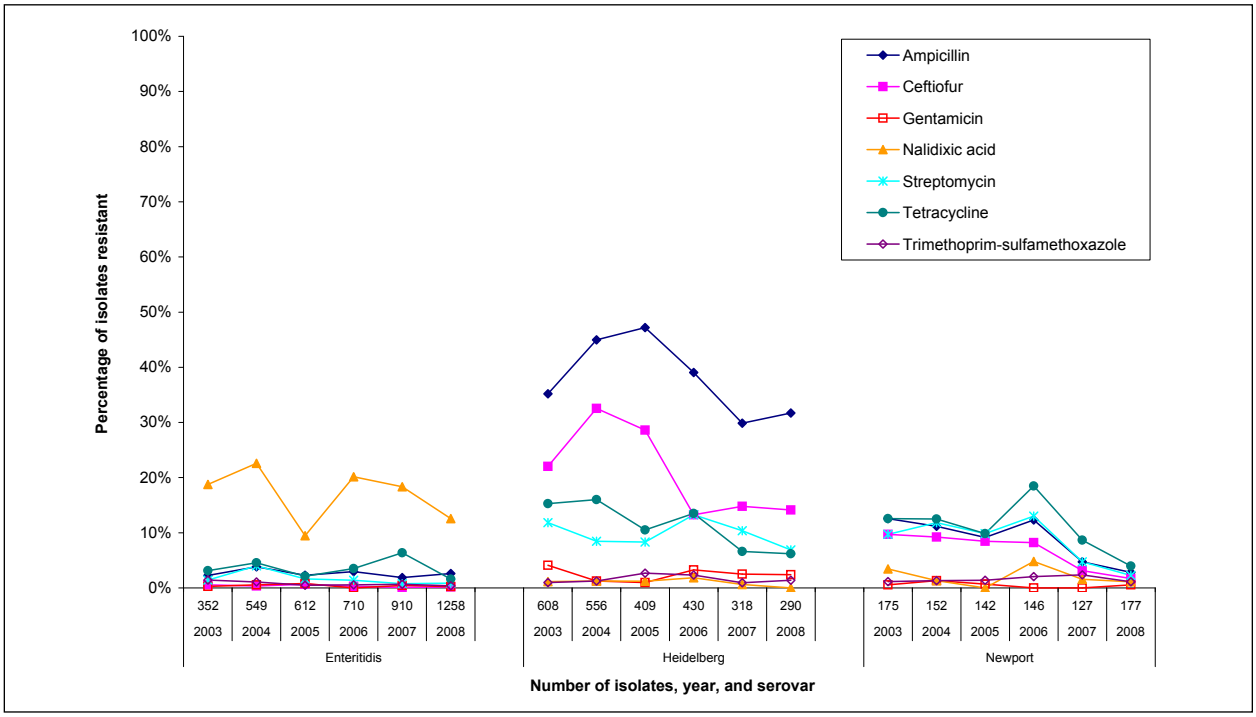
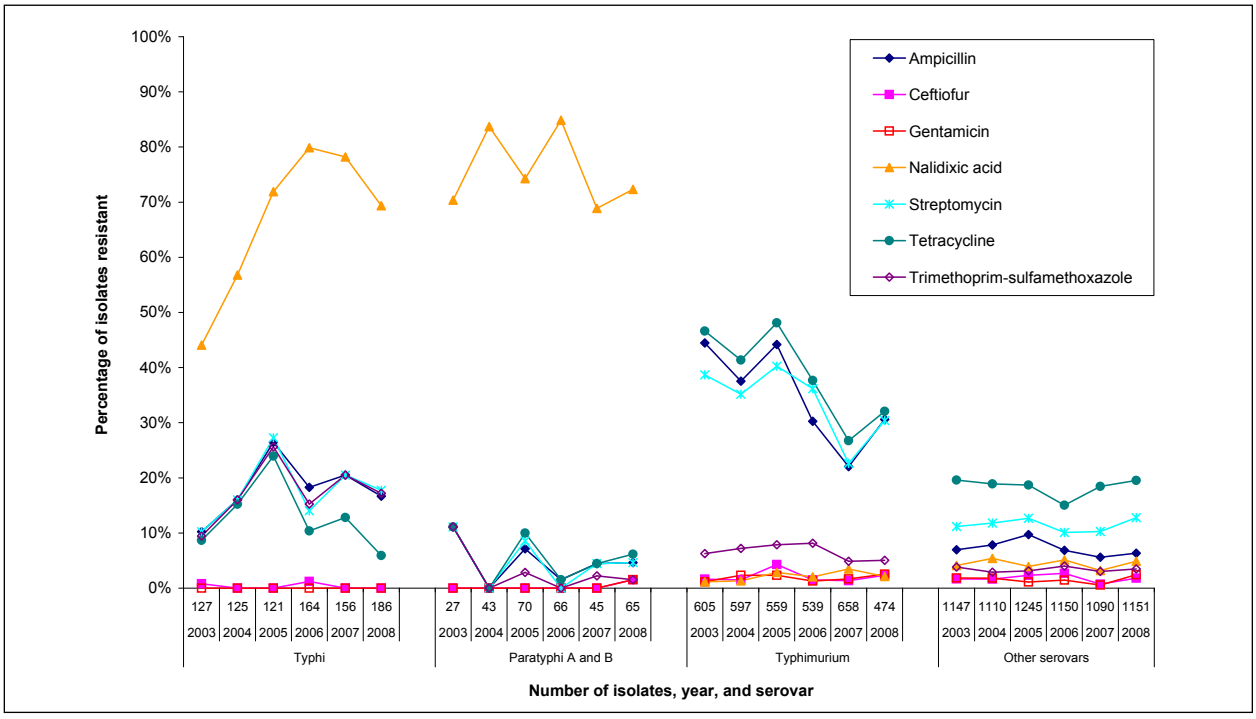


FIGURE 3. Temporal variation in resistance to selected antimicrobials in human *Salmonella* isolates, serovars Paratyphi A and B, Typhi, Typhimurium, and "Other Serovars"; *Surveillance of Human Clinical Isolates*, 2003-2008.



Salmonella

Surveillance of Animal Clinical Isolates[1]

(n = 134)

Note: These isolates may be from either dairy or beef cattle.

Serovars: Results are presented in Table 9 and Table C.3, Appendix C. The most common *Salmonella* serovars were Typhimurium (22%, 30/134), Typhimurium var. 5- (19%, 25/134), and Kentucky (11%, 15/134). These 3 serovars accounted for 52% (70/134) of the isolates.

Antimicrobial Resistance: Results are presented in Table B.8, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 4% (6/134) of *Salmonella* isolates. Reduced susceptibility to ciprofloxacin was detected in 1% (1/134) of the isolates. None of the isolates were resistant to ciprofloxacin, amikacin, or nalidixic acid.

Antimicrobial Resistance Patterns: Results are presented in Table 9 and Table C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 39% (52/134) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 28% (38/134) of isolates (21 *S.* Typhimurium var. 5-, 13 *S.* Typhimurium, 3 *S.* Heidelberg, and 1 *S.* Agona). The most common resistance patterns were ACKSSuT (7%, 10/134), ACKSSuT-GEN (5%, 7/134), and ACSSuT (4%, 6/134). Seven of the 10 isolates with the ACKSSuT resistance pattern were *S.* Typhimurium var. 5-, and 3 were *S.* Typhimurium. One percent (1/134) of isolates had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. The resistance pattern involving the greatest number of antimicrobials among isolates was ACKSSuT-A2C-CRO-SXT (3 *S.* Typhimurium PT 108).

In 2008, the most common resistance patterns in cattle clinical isolates of *Salmonella* were ACKSSuT (7%, 10/134), ACKSSuT-GEN (5%, 7,134), and ACSSuT (4%, 6/134). Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 4% (6/134) of the isolates. One percent (1/134) of isolates had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. The resistance pattern involving the greatest number of antimicrobials was ACKSSuT-A2C-CRO-SXT (3 *S.* Typhimurium PT 108).

TABLE 9. Number of antimicrobials in resistance patterns of *Salmonella* isolates from cattle, by serovar; *Surveillance of Animal Clinical Isolates*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Typhimurium	30 (22.4)	10	7	10	3
Typhimurium var. 5-	25 (18.7)	2	2	21	0
Kentucky	15 (11.2)	15	0	0	0
Cerro	13 (9.7)	13	0	0	0
I 6,14,18:-:-	10 (7.5)	10	0	0	0
Heidelberg	9 (6.7)	3	3	3	0
Muenster	8 (6.0)	8	0	0	0
Enteritidis	4 (3.0)	3	1	0	0
Thompson	4 (3.0)	4	0	0	0
Less common serovars	16 (11.9)	14	1	0	1
Total	**134 (100)**	**82**	**14**	**34**	**4**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

[1] Distribution of *Salmonella* isolates across provinces is presented in Table C.6, Appendix C.

Abattoir Surveillance

(n = 176)

Recovery: *Escherichia coli* isolates were recovered from 97% (176/182) of beef cattle caecal samples (Table C.5, Appendix C).

Antimicrobial Resistance: Results are presented in Figure 4 and Table B.9, Appendix B. None of the *E. coli* isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, gentamicin, nalidixic acid, or trimethoprim-sulfamethoxazole. Additionally, none of the isolates had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 39% (69/176) of *E. coli* isolates. None of the isolates were resistant to 5 or more antimicrobials. The most common resistance patterns were TET (17%, 30/176) and SSS-TET (5%, 9/176). The patterns including the greatest number of antimicrobials were CHL-STR-SSS-TET and KAN-STR-SSS-TET, which were each detected in 4 isolates, 1 of which had both patterns.

Temporal Variations: Results are presented in Figure 5. Between 2008 and 2003 and between 2008 and 2007, there were no significant temporal variations in percentages of *E. coli* isolates resistant to the selected antimicrobials.

In 2008, resistance to 1 or more antimicrobials was detected in 39% (69/176) of abattoir beef cattle isolates of *Escherichia coli*. The most common resistance patterns were TET (17%, 30/176) and SSS-TET (5%, 9/176). None of the isolates were resistant to the Category I antimicrobials tested, and none were resistant to 5 or more antimicrobials.

FIGURE 4. Resistance to antimicrobials in *Escherichia coli* isolates from beef cattle; *Abattoir Surveillance,* 2008.

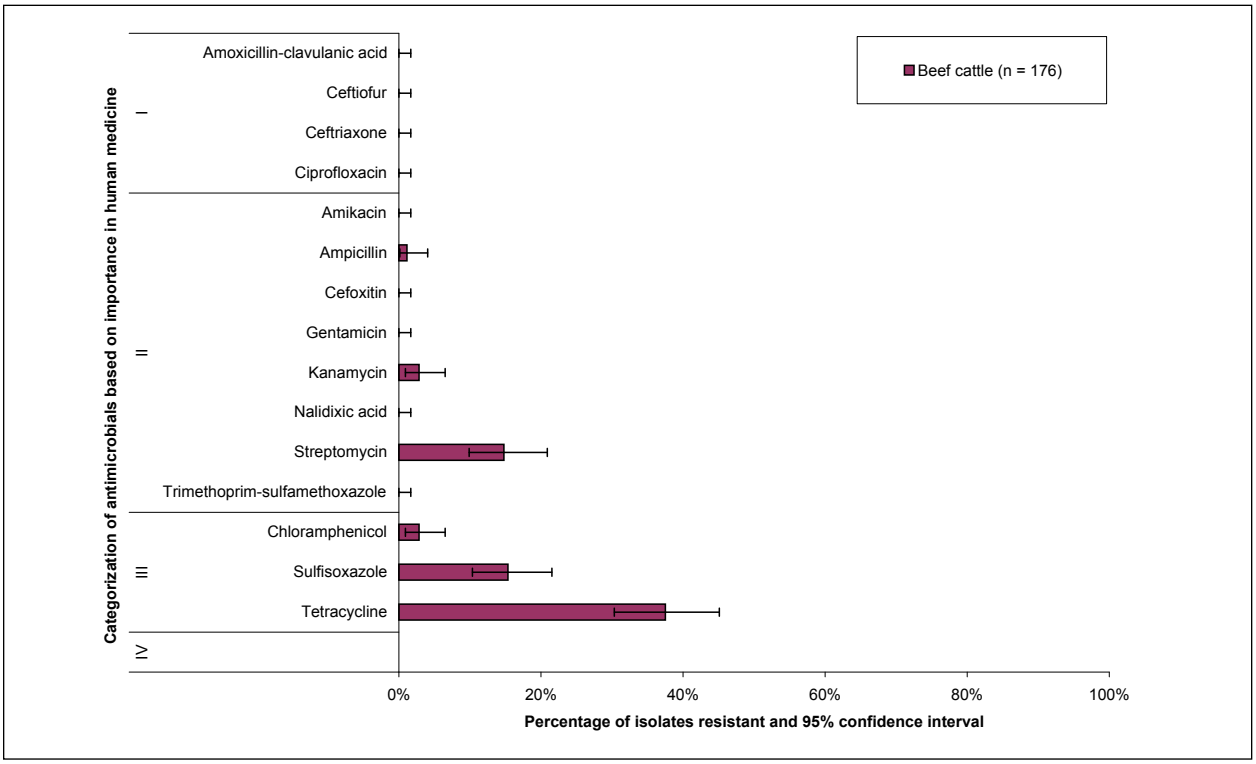
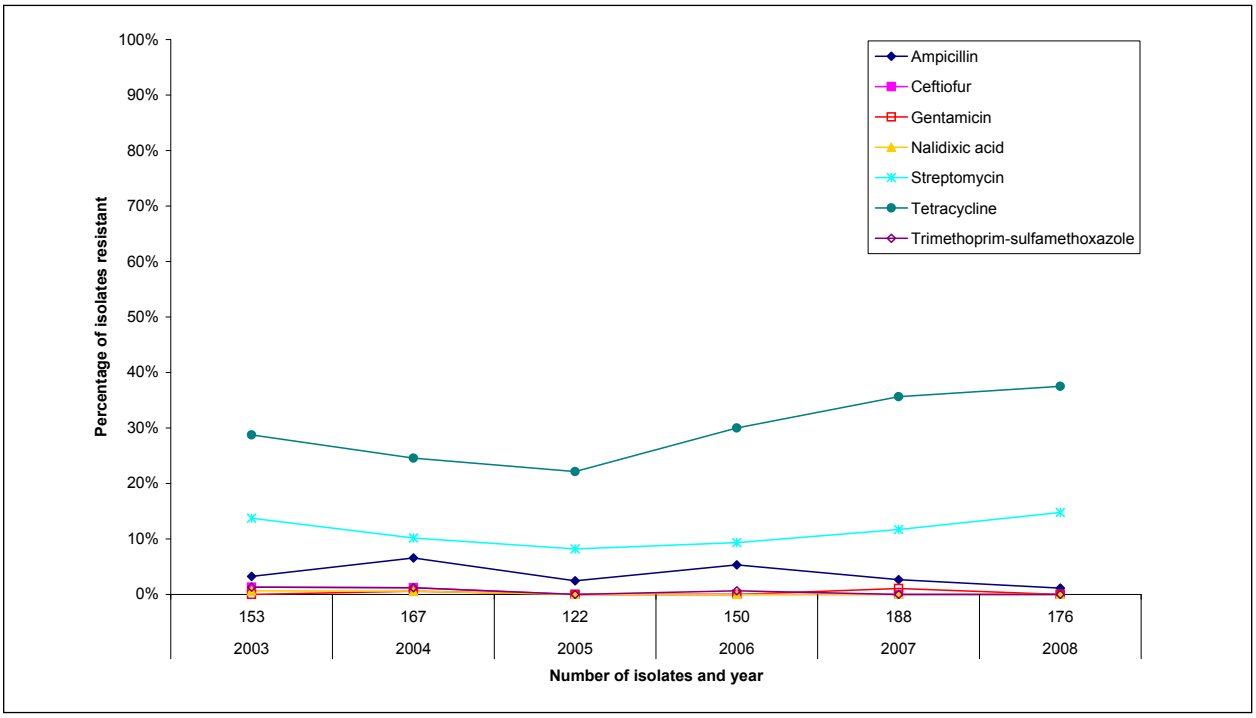


FIGURE 5. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from beef cattle; *Abattoir Surveillance*, 2003-2008.



Retail Meat Surveillance

(n = 572)
(British Columbia [n = 88], Saskatchewan [n = 134], Ontario [n = 185], Québec [n = 126], Maritimes region [n = 39])

Recovery: *Escherichia coli* isolates were recovered from 72% (572/798) of retail beef samples. Province/region-specific percentages of beef samples from which isolates were recovered were as follows: British Columbia, 77% (88/115); Saskatchewan, 76% (134/177); Ontario, 78% (185/236); Québec, 59% (126/214); and the Maritimes region, 70% (39/56; Table C.5, Appendix C).

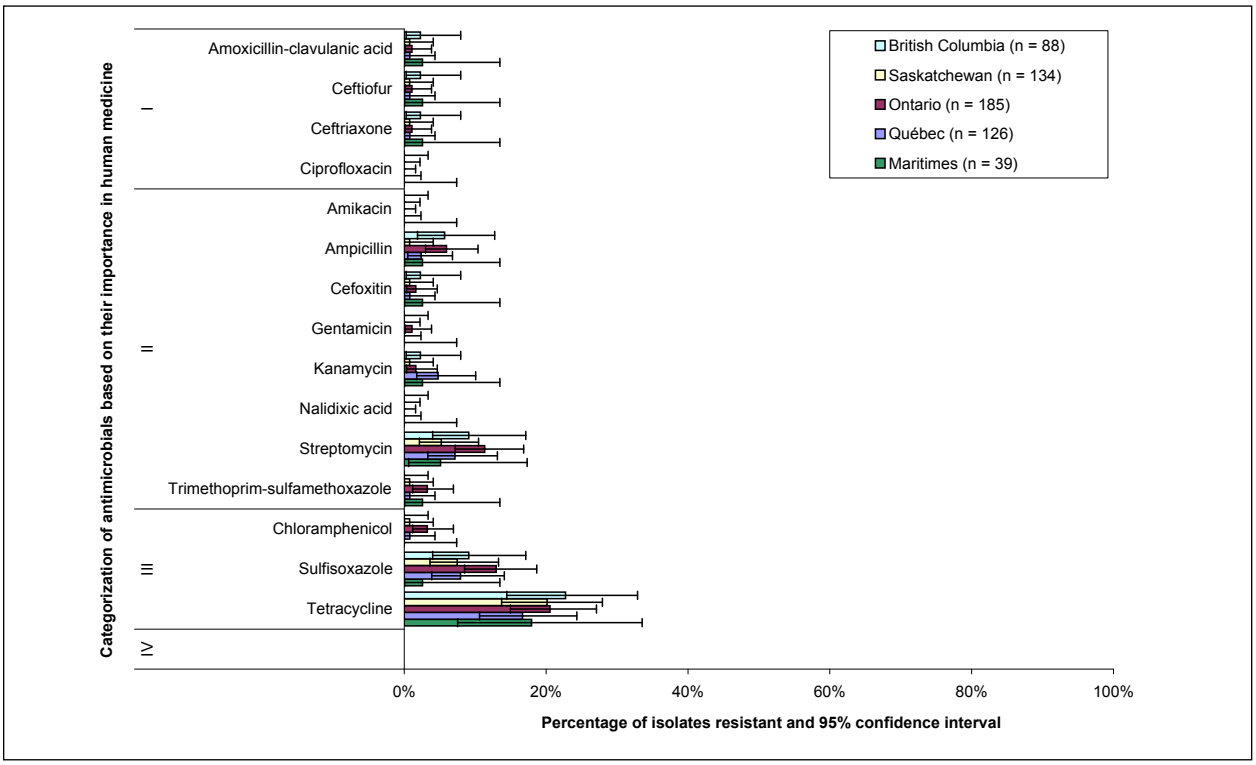
Antimicrobial Resistance: Results are presented in Figure 6 and Table B.10, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 2% (2/88) of *E. coli* isolates from British Columbia, 1% (1/134) of isolates from Saskatchewan, 1% (2/185) of isolates from Ontario, 1% (1/126) of isolates from Québec, and 3% (1/39) of isolates from the Maritimes region. There were no significant differences among the provinces/region in percentages of isolates with resistance to any antimicrobial tested. None of the isolates from any province/region were resistant to ciprofloxacin, amikacin, or nalidixic acid or had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 28% (25/88) of *E. coli* isolates from British Columbia, 22% (29/134) of isolates from Saskatchewan, 23% (43/185) of isolates from Ontario, 18% (23/126) of isolates from Québec, and 21% (8/39) of isolates from the Maritimes region. Resistance to 5 or more antimicrobials was detected in 3% (3/88) of isolates from British Columbia, 1% (1/134) of isolates from Saskatchewan, 3% (6/185) of isolates from Ontario, 1% (1/126) of isolates from Québec, and 3% (1/39) of isolates from the Maritimes region. Among the isolates from all 5 provinces/region, the most common resistance patterns were TET (9%, 51/572) and SSS-TET (3%, 15/572). The resistance pattern involving the greatest number of antimicrobials among isolates was AKSSuT-A2C-CRO, which was detected in 1 isolate from Québec.

Temporal Variations: Results are presented in Figure 7. The percentage of *E. coli* isolates from Saskatchewan with resistance to tetracycline was significantly higher in 2008 (20%, 27/134) than in 2007 (8%, 9/118) and 2005 (9%, 11/120). The percentage of isolates from Ontario with resistance to streptomycin was significantly higher in 2008 (11%, 21/185) than in 2007 (3%, 6/187). For the other provinces/region, there were no significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

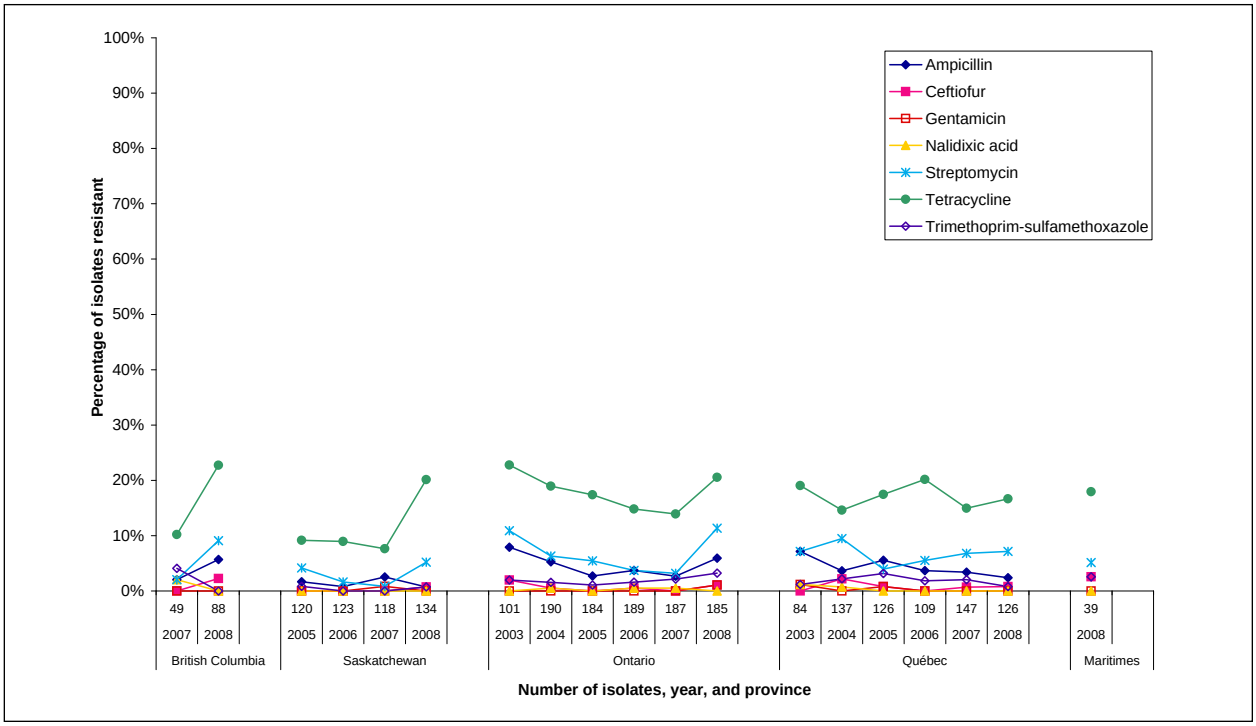
In 2008, the percentage of retail beef *Escherichia coli* isolates from Saskatchewan with resistance to tetracycline (20%, 27/134) was significantly higher than in 2007 (8%, 9/118) and 2005 (9%, 11/120). The percentage of isolates from Ontario with resistance to streptomycin was significantly higher in 2008 (11%, 21/185) than in 2007 (3%, 6/187).

FIGURE 6. Resistance to antimicrobials in *Escherichia coli* isolates from beef; *Retail Meat Surveillance*, 2008.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

FIGURE 7. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from beef; *Retail Meat Surveillance*, 2003-2008.



Campylobacter

Abattoir Surveillance

(n = 128)

Recovery: *Campylobacter* isolates were recovered from 71% (129/182) of beef cattle caecal samples (Table C.5, Appendix C). One isolate could not be cultured after freezing, leaving 128 isolates for antimicrobial susceptibility testing. Twenty-three percent (30/128) of the remaining isolates were *C. coli*, 73% (93/128) were *C. jejuni*, and 4% (5/128) were other *Campylobacter* spp.

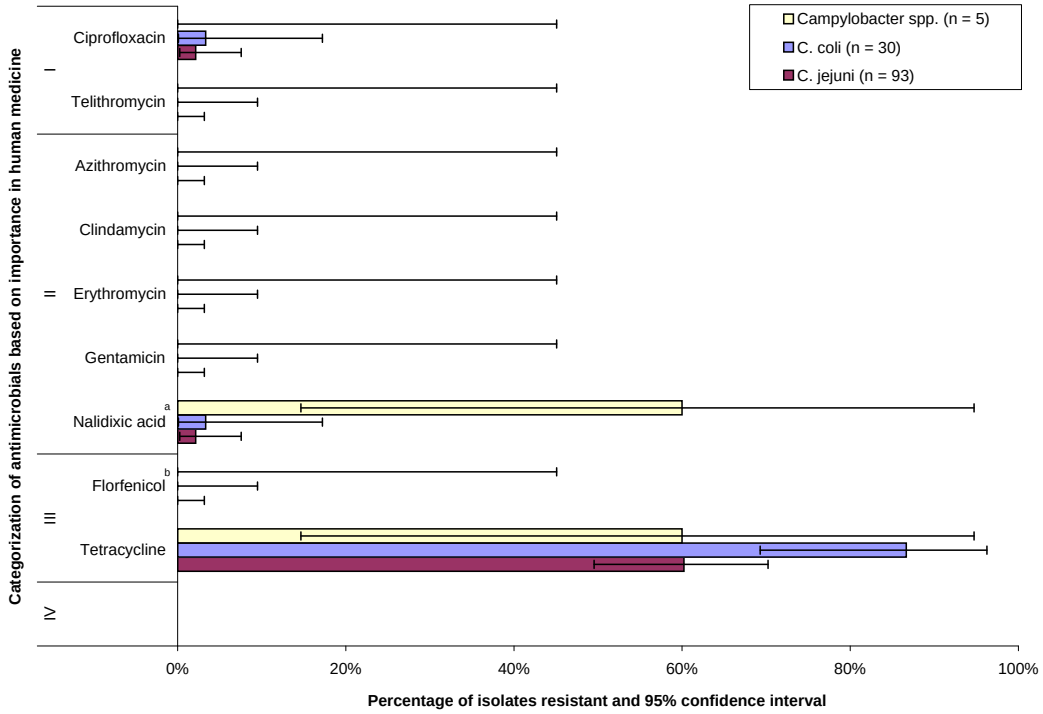
Antimicrobial Resistance: Results are presented in Figure 8 and Table B.11, Appendix B. Resistance to ciprofloxacin was detected in 2% (3/128) of *Campylobacter* isolates (1 *C. coli* and 2 *C. jejuni*). None of the isolates were resistant to telithromycin, azithromycin, clindamycin, erythromycin, or gentamicin, and none were non-susceptible to florfenicol.

Antimicrobial Resistance Patterns: Results are presented in Table 10. Resistance to 1 or more antimicrobials was detected in 67% (86/128) of *Campylobacter* isolates. Resistance to 3 antimicrobials was detected in 2% (2/128). The most common resistance pattern was TET (63%, 80/128). The pattern with the greatest number of antimicrobials was CIP-NAL-TET, which was detected in 2 *C. jejuni* isolates.

Temporal Variations: Results are presented in Figure 9. Between 2008 and 2006 and between 2008 and 2007, there were no significant temporal variations in the percentages of *Campylobacter* isolates with resistance to the selected antimicrobials.

In 2008, resistance to 1 or more antimicrobials was detected in 67% (86/128) of abattoir beef cattle isolates of *Campylobacter*. Resistance to ciprofloxacin was detected in 2% (3/128) of isolates (1 *C. coli* and 2 *C. jejuni*). The pattern with the greatest number of antimicrobials was CIP-NAL-TET, which was detected in 2 *C. jejuni* isolates.

FIGURE 8. Resistance to antimicrobials in *Campylobacter* isolates from beef cattle; *Abattoir Surveillance*, 2008.



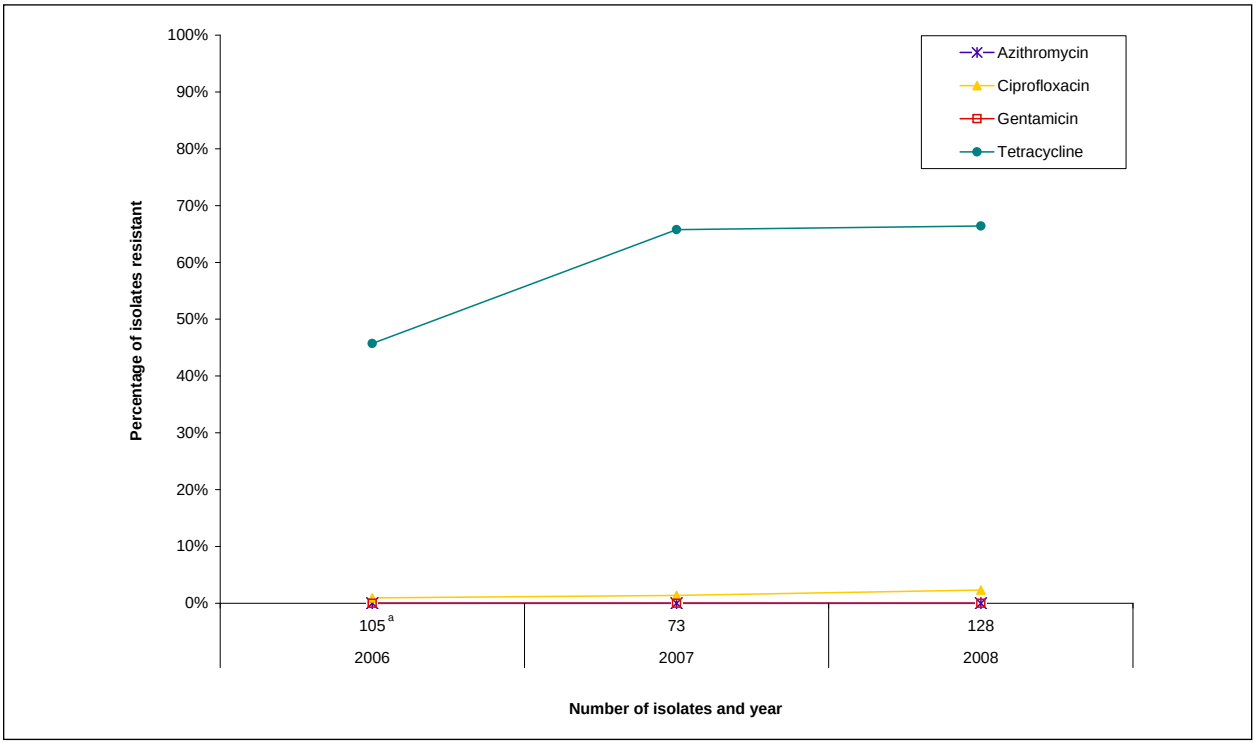
[a] *Campylobacter* spp. include unidentified species, some of which may be intrinsically resistant to nalidixic acid.

[b] Non-susceptibility to florfenicol is presented as there is currently a susceptibility breakpoint but no resistance breakpoint for this antimicrobial.

TABLE 10. Number of antimicrobials in resistance patterns of *Campylobacter* isolates from beef cattle, by *Campylobacter* species; *Abattoir Surveillance*, 2008.

Species	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 2	3 - 4	5 - 9
		Number of isolates			
C. jejuni	93 (72.7)	37	56	0	0
C. coli	30 (23.4)	3	27	0	0
Campylobacter spp.	5 (3.9)	2	3	0	0
Total	**128 (100)**	**42**	**86**	**0**	**0**

FIGURE 9. Temporal variation in resistance to selected antimicrobials in *Campylobacter* isolates from beef cattle; *Abattoir Surveillance*, 2006-2008.



[a] This number of isolates includes isolates from year 2005 (n = 23).

Salmonella

Abattoir Surveillance

(n = 234)

Recovery: *Salmonella* isolates were recovered from 27% (234/851) of chicken caecal samples (Table C.5, Appendix C).

Serovars: Results are presented in Table 11 and Table C.2, Appendix C. The most common *Salmonella* serovars were Kentucky (40%, 93/234), Enteritidis (19%, 45/234), and Heidelberg (14%, 33/234). These 3 serovars accounted for 73% (171/234) of the isolates.

Antimicrobial Resistance: Results are presented in Figure 10 and Table B.12, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 12% (27/234) of *Salmonella* isolates. None of the isolates were resistant to ciprofloxacin, amikacin, nalidixic acid, or trimethoprim-sulfamethoxazole. Additionally, none had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 11 and Table C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 52% (121/234) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 12% (28/234) of the isolates (17 *S.* Kentucky, 6 *S.* Heidelberg, 2 *S.* Kiambu, 1 *S.* Infantis, 1 *S.* Typhimurium, and 1 *S.* Typhimurium var. 5-). The most common resistance patterns were STR-TET (29%, 69/234) and A2C-AMP-CRO (5%, 12/234). The main serovar associated with the STR-TET pattern was Kentucky (77%, 53/69). The patterns involving the greatest number of antimicrobials among isolates were A2C-AMP-CRO-STR-SSS and A2C-AMP-CRO-STR-TET, which were detected in 1 and 10 *S.* Kentucky isolates, respectively.

Temporal Variations: Results are presented in Figure 11. The percentage of *Salmonella* isolates with resistance to tetracycline was significantly higher in 2008 (41%, 96/234) than in 2003 (19%, 24/126). The percentages of isolates with resistance to ceftiofur and ampicillin were significantly lower in 2008 (12% and 16% [38/234], respectively) than in 2004 (22% [31/142] and 28% [39/142], respectively).[1]

In 2008, the percentage of abattoir chicken *Salmonella* isolates with resistance to tetracycline (41%, 96/234) was significantly higher than in 2003 (19%, 24/126). The percentages of isolates with resistance to ceftiofur and ampicillin were significantly lower in 2008 (12% [27/234] and 16% [38/234], respectively) than in 2004 (22% [31/142] and 28% [39/142], respectively).

TABLE 11. Number of antimicrobials in resistance patterns of *Salmonella* isolates from chickens, by serovar; *Abattoir Surveillance*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Kentucky	93 (39.7)	18	58	17	0
Enteritidis	45 (19.2)	45	0	0	0
Heidelberg	33 (14.1)	19	8	6	0
Hadar	13 (5.6)	0	13	0	0
Typhimurium	7 (3.0)	5	1	1	0
Mbandaka	5 (2.1)	5	0	0	0
Rissen	5 (2.1)	1	4	0	0
Less common serovars	33 (14.1)	20	9	4	0
Total	**234 (100)**	**113**	**93**	**28**	**0**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

[1] 2004 and 2006 were selected as years of comparison for ceftiofur and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005 and in 2006 (start and end of the voluntary period of withdrawal).

FIGURE 10. Resistance to antimicrobials in *Salmonella* isolates from chickens; *Abattoir Surveillance*, 2008.

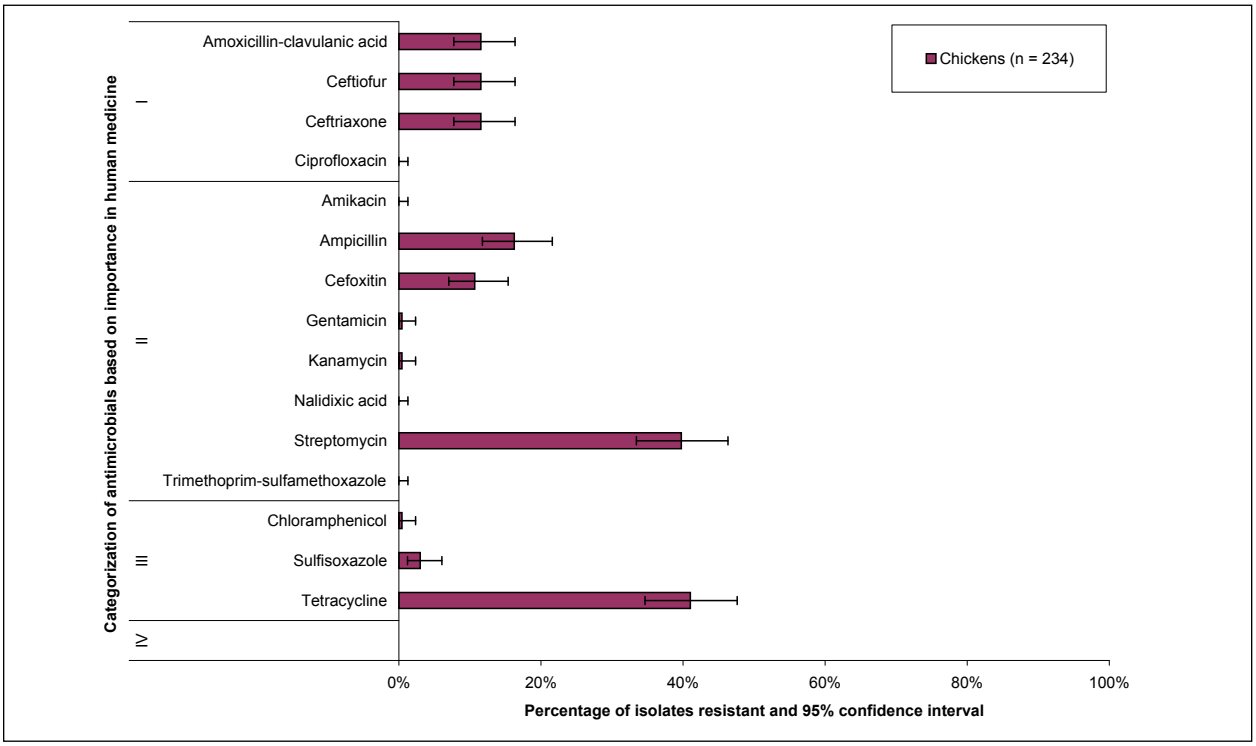
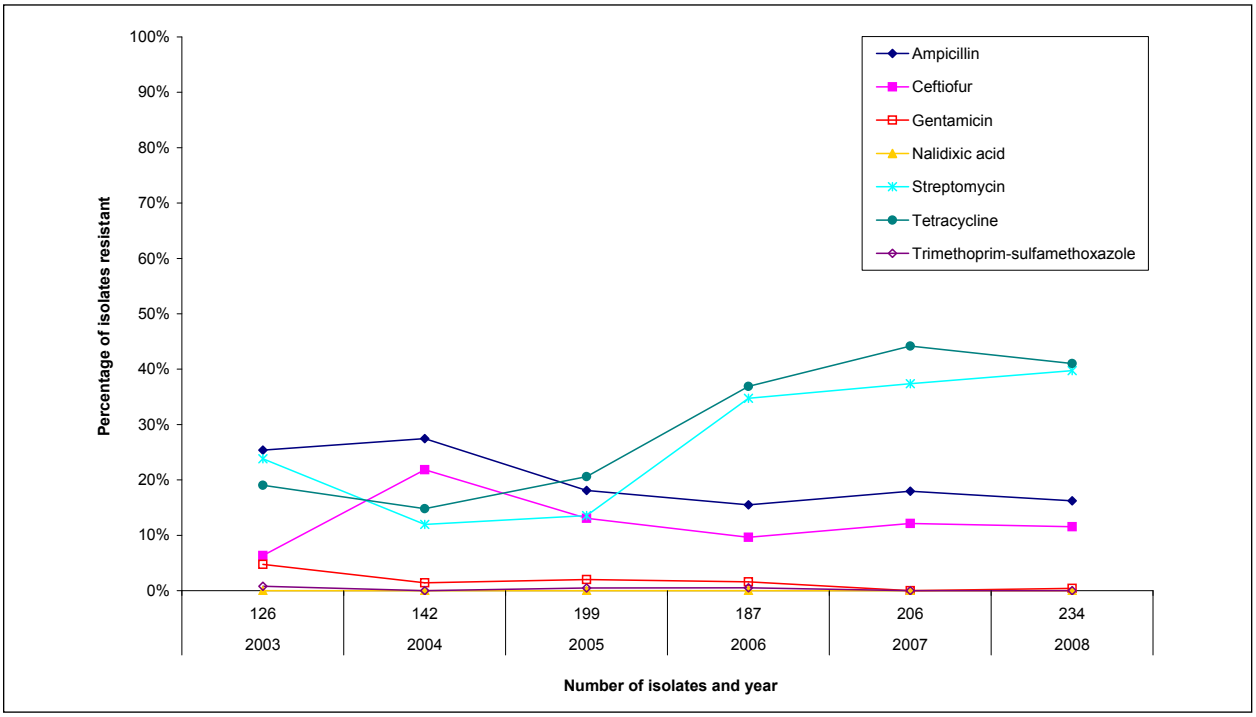


FIGURE 11. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from chickens; *Abattoir Surveillance*, 2003-2008.



Retail Meat Surveillance

(n = 382)
(British Columbia [n = 47], Saskatchewan [n = 64], Ontario [n = 139], Québec [n = 120], Maritimes region [n = 12])

Recovery: *Salmonella* isolates were recovered from 40% (382/960) of retail chicken samples (Table C.5, Appendix C). Province/region-specific percentages of chicken samples from which isolates were recovered were as follows: British Columbia, 32% (47/145); Saskatchewan, 40% (64/161); Ontario, 45% (139/311); Québec, 42% (120/287); and the Maritimes region, 22% (12/56).

Serovars: Results are presented in Table 12 and Table C.2, Appendix C. The most common *Salmonella* serovars were Kentucky (31%, 120/382), Heidelberg (20%, 78/382), Enteritidis (16%, 62/382), and Hadar (6%, 22/382). The most common serovars by province/region were Enteritidis (30%, 14/47) and Kentucky (28%, 13/47) for British Columbia; Kentucky (23%, 15/64) and Enteritidis (22%, 14/64) for Saskatchewan; Kentucky (33%, 46/139) and Enteritidis (16%, 22/139) for Ontario; Kentucky (37%, 44/120) and Heidelberg (32%, 38/120) for Québec; and Heidelberg (4/12) and Thompson (3/12) for the Maritimes region.

Antimicrobial Resistance: Results are presented in Figure 12 and Table B.13, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 21% (10/47), 23% (11/47), and 23% (11/47) of *Salmonella* isolates from British Columbia, respectively, and resistance to each was also detected in 5% (3/64) of isolates from Saskatchewan. Nine percent (13/139) of isolates from Ontario were resistant to amoxicillin-clavulanic acid, and ceftiofur and ceftriaxone resistance were each detected in 10% (14/139). Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 15% (18/120) of isolates from Québec, and resistance to each was also detected in 2 of 12 isolates from the Maritimes region. There were no significant differences among the provinces/region in percentages of isolates with resistance to any of the antimicrobials tested. None of the isolates from the 5 provinces/region were resistant to ciprofloxacin, amikacin, or nalidixic acid. Reduced susceptibility to ciprofloxacin was not detected in any isolates.

Antimicrobial Resistance Patterns: Results are presented in Table 12. Resistance to 1 or more antimicrobials was detected in 40% (19/47) of *Salmonella* isolates from British Columbia, 44% (28/64) of isolates from Saskatchewan, 47% (65/139) of isolates from Ontario, 54% (65/120) of isolates from Québec, and 3 of 12 isolates from the Maritimes region. Resistance to 5 or more antimicrobials was detected in 26% (12/47) of isolates from British Columbia (8 *S.* Kentucky, 2 *S.* Heidelberg, 1 *S.* Typhimurium, and 1 *Salmonella* ssp. I 4,[5],12:-:-), 6% (4/64) of isolates from Saskatchewan (1 *S.* Heidelberg, 1 *S.* Infantis, 1 *S.* Typhimurium, and 1 *Salmonella* ssp. I 4,[5],12:-:-), 10% (14/139) of isolates from Ontario (3 *S.* Heidelberg, 3 *S.* Kentucky, 3 *S.* Kiambu, 1 *S.* Agona, 1 *S.* Thompson, 1 *S.* Typhimurium var. 5-, 1 *Salmonella* ssp. I 8,20:-:z6, and 1 *Salmonella* ssp. I Rough:r:1,2), 14% (17/120) of isolates from Québec (6 *S.* Heidelberg, 6 *S.* Kentucky, 3 *S.* Kiambu, 1 *S.* Infantis, and 1 *S.* Typhimurium var. 5-), and 2 of 12 isolates from the Maritimes region (1 *S.* Heidelberg and 1 *Salmonella* ssp. I 4,[5],12:-:-). Among isolates from all 5 provinces/region, the most common resistance patterns were STR-TET (21%, 81/382), A2C-AMP-CRO (7%, 25/382), and TET (4%, 17/382). The resistance patterns involving the greatest number of antimicrobials among isolates were A2C-AMP-CRO-SSS-TET-SXT and A2C-AMP-CRO-GEN-STR-SSS, which were detected in 1 isolate from Ontario (*S.* Kiambu) and 1 from the Maritimes region (*Salmonella* ssp. I 4,[5],12:-:-), respectively.

Temporal Variations: Results are presented in Figure 13. The percentage of isolates from Saskatchewan with resistance to nalidixic acid was significantly lower in 2008 (0%) than in 2005 (10%, 2/21). The percentages of isolates from Ontario with resistance to ampicillin and ceftiofur were significantly lower in 2008 (14% [19/139] and 10%, respectively) than in 2004[1] (51% [28/55] and 45% [25/55], respectively). The percentages of isolates from Ontario with resistance to streptomycin and tetracycline were significantly higher in 2008 (32% [45/139] and 36% [50/139], respectively) than in 2003 (4% [1/26] and 0% [0/26], respectively). The percentages of isolates from Québec with resistance to ampicillin and ceftiofur were significantly lower in 2008 (21% [25/120] and 15%, respectively) than in 2004 (47% [28/60] and 37% [22/60], respectively). In the other provinces/region, there were no significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In Saskatchewan, the percentage of retail chicken *Salmonella* isolates with resistance to nalidixic acid was significantly lower in 2008 (0%, 0/64) than in 2005 (10%, 2/21). The percentages of isolates from Ontario with resistance to streptomycin and tetracycline were significantly higher in 2008 (32% [45/139] and 36% [50/139], respectively) than in 2003 (4% [1/26] and 0% [0/26], respectively). The percentages of isolates from Québec with resistance to ampicillin and ceftiofur were significantly lower in 2008 (21% [25/120] and 15% [18/120], respectively) than in 2004 (47% [28/60] and 37% [22/60], respectively).

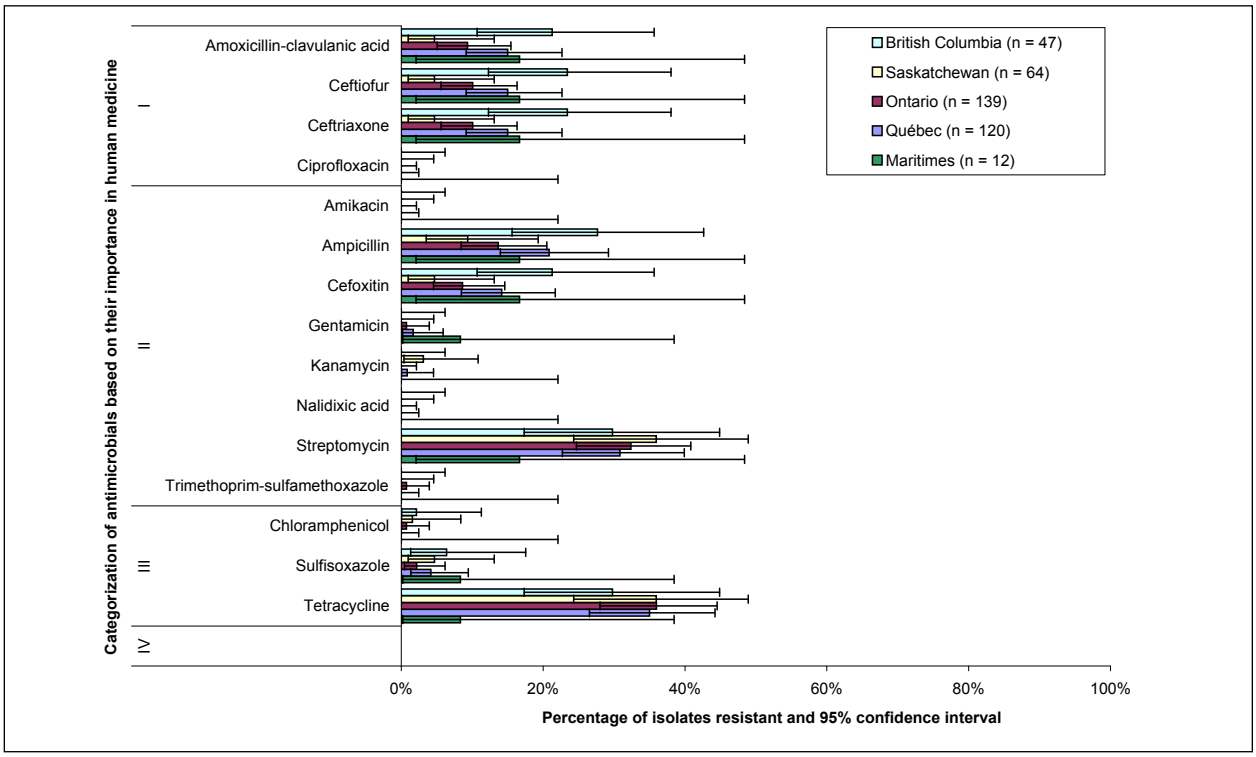
[1] 2004 and 2006 were selected as years of comparison for ceftiofur and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005 and in 2006 (start and end of the voluntary period of withdrawal).

TABLE 12. Number of antimicrobials in resistance patterns of *Salmonella* isolates from chicken, by province/region and serovar; *Retail Meat Surveillance,* 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
British Columbia					
Enteritidis	14 (29.8)	14	0	0	0
Kentucky	13 (27.7)	1	4	8	0
Hadar	3 (6.4)	1	2	0	0
Heidelberg	3 (6.4)	0	1	2	0
Mbandaka	3 (6.4)	3	0	0	0
Typhimurium	3 (6.4)	2	0	1	0
I 4,[5],12:i:-	2 (4.3)	1	0	1	0
Senftenberg	2 (4.3)	2	0	0	0
Meleagridis	1 (2.1)	1	0	0	0
Rissen	1 (2.1)	1	0	0	0
Schwarzengrund	1 (2.1)	1	0	0	0
Thompson	1 (2.1)	1	0	0	0
Total	47 (100)	28	7	12	0
Saskatchewan					
Kentucky	15 (23.4)	3	12	0	0
Enteritidis	14 (21.9)	14	0	0	0
Heidelberg	12 (18.8)	7	4	1	0
I 4,[5],12:i:-	7 (10.9)	6	0	1	0
Hadar	6 (9.4)	0	6	0	0
Infantis	3 (4.7)	2	0	1	0
Mbandaka	2 (3.1)	1	1	0	0
Less common serovars	5 (7.8)	3	1	1	0
Total	64 (100)	36	24	4	0
Ontario					
Kentucky	46 (33.1)	10	33	3	0
Enteritidis	22 (15.8)	22	0	0	0
Heidelberg	21 (15.1)	17	1	3	0
Hadar	11 (7.9)	0	11	0	0
Kiambu	7 (5.0)	2	2	3	0
Thompson	7 (5.0)	6	0	1	0
Typhimurium	6 (4.3)	6	0	0	0
Schwarzengrund	4 (2.9)	2	2	0	0
Infantis	3 (2.2)	3	0	0	0
Less common serovars	12 (8.6)	6	2	4	0
Total	139 (100)	74	51	14	0
Québec					
Kentucky	44 (36.7)	6	32	6	0
Heidelberg	38 (31.7)	22	10	6	0
Enteritidis	11 (9.2)	11	0	0	0
Thompson	6 (5.0)	6	0	0	0
Kiambu	5 (4.2)	1	1	3	0
I 6,7:-:1,5	3 (2.5)	3	0	0	0
Schwarzengrund	3 (2.5)	1	2	0	0
Less common serovars	10 (8.3)	5	3	2	0
Total	120 (100)	55	48	17	0
Maritimes					
Heidelberg	4 (33.3)	3	0	1	0
Thompson	3 (25.0)	3	0	0	0
Kentucky	2 (16.7)	1	1	0	0
Enteritidis	1 (8.3)	1	0	0	0
I 4,[5],12:-:-	1 (8.3)	0	0	1	0
I 6,7:k:-	1 (8.3)	1	0	0	0
Total	12 (100)	9	1	2	0
Total	**382 (100)**	**202**	**131**	**49**	**0**

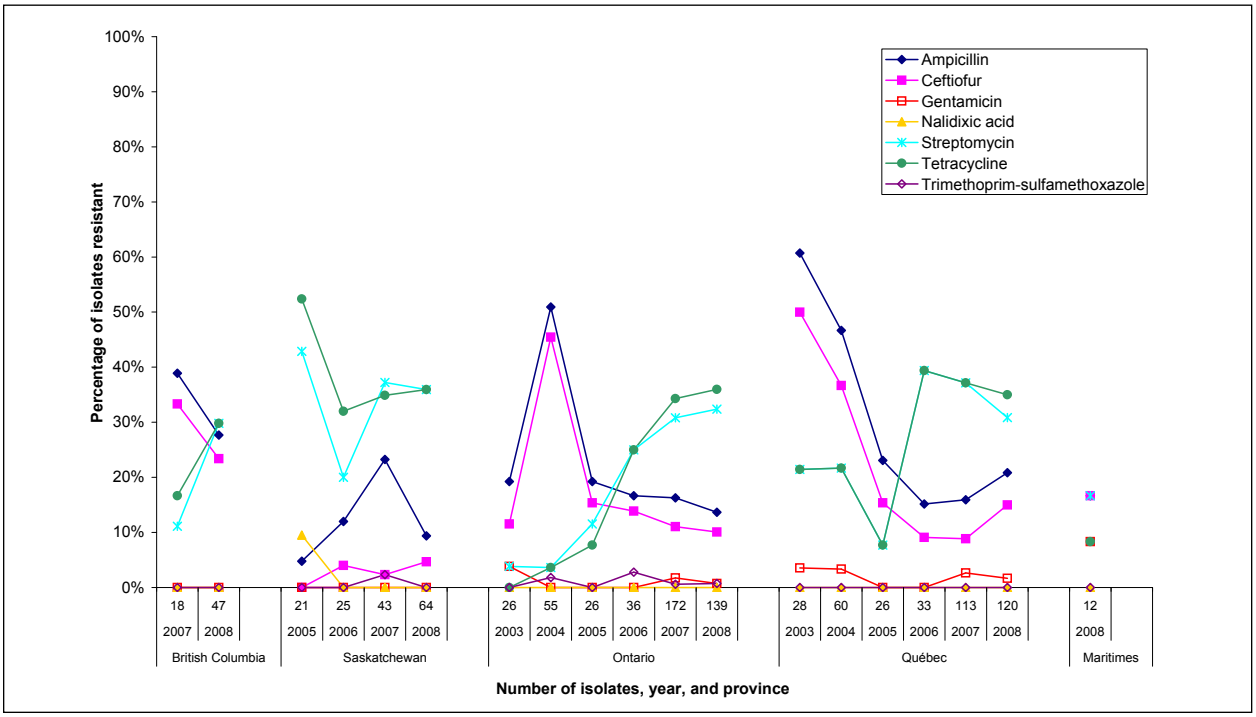
Serovars represented by less than 2% of isolates were classified as "Less common serovars."
The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

FIGURE 12. Resistance to antimicrobials in *Salmonella* isolates from chicken; *Retail Meat Surveillance*, 2008.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

FIGURE 13. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from chicken; *Retail Meat Surveillance*, 2003-2008.



Surveillance of Animal Clinical Isolates[1]

(n = 209)

Note: These isolates may be from layer hens or broiler chickens, or from their environment.

Serovars: Results are presented in Table 13 and Table C.2, Appendix C. The most common *Salmonella* serovars were Enteritidis (47%, 99/209), Kentucky (18%, 38/209), and Heidelberg (15%, 31/209). These 3 serovars accounted for 80% (168/209) of the isolates.

Antimicrobial Resistance: Results are presented in Table B.14, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 16% (33/209, 34/209, and 34/209, respectively) of *Salmonella* isolates. None of the isolates were resistant to ciprofloxacin, amikacin, nalidixic acid, or trimethoprim-sulfamethoxazole, and none had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 13 and Table C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 32% (66/209) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 17% (35/209) of the isolates (including 19 *S.* Kentucky and 6 *S.* Heidelberg). The most common resistance patterns were A2C-AMP-CRO (7%, 15/209), A2C-AMP-CRO-STR-TET (5%, 10/209), and TET (5%, 10/209). Fifteen isolates had the A2C-AMP-CRO resistance pattern, including serovars Kentucky (7/15) and Heidelberg (5/15). Isolates with the A2C-AMP-CRO-STR-TET resistance pattern were all *S.* Kentucky. The pattern involving the greatest number of antimicrobials was ACKSSuT-A2C-CRO-GEN (1 *S.* Mbandaka).

In 2008, resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 16% (33/209, 34/209, and 34/209, respectively) of chicken clinical *Salmonella* isolates. Isolates with the A2C-AMP-CRO-STR-TET resistance pattern (5%, 10/209) were all *S.* Kentucky. The pattern involving resistance to the greatest number of antimicrobials was ACKSSuT-A2C-CRO-GEN (1 *S.* Mbandaka).

TABLE 13. Number of antimicrobials in resistance patterns of *Salmonella* isolates from chickens, by serovar; *Surveillance of Animal Clinical Isolates*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Enteritidis	99 (47.4)	99	0	0	0
Kentucky	38 (18.2)	4	15	19	0
Heidelberg	31 (14.8)	20	5	6	0
Typhimurium	10 (4.8)	5	2	3	0
I 4,[5],12:i:-	5 (2.4)	3	0	2	0
Less common serovars	26 (12.4)	12	9	1	4
Total	**209 (100)**	**143**	**31**	**31**	**4**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

[1] Distribution of *Salmonella* isolates across provinces is presented in Table C.6, Appendix C.

Abattoir Surveillance

(n = 170)

Recovery: *Escherichia coli* isolates were recovered from 99% (170/171) of abattoir chicken caecal samples (Table C.5, Appendix C).

Antimicrobial Resistance: Results are presented in Figure 14 and Table B.15, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were detected in 26% (45/170), 20% (34/170), and 23% (39/170) of the *E. coli* isolates, respectively. Three percent (5/170) of isolates had reduced susceptibility to ciprofloxacin. Resistance to nalidixic acid was detected in 4% (6/170) of isolates. None of the isolates were resistant to ciprofloxacin or amikacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 77% (131/170) of *E. coli* isolates. Resistance to 5 or more antimicrobials was detected in 31% (52/170). The most common resistance patterns were TET (6%, 11/170) and A2C-AMP-CRO (6%, 11/170), as well as STR-TET (5%, 9/170). Reduced susceptibility to ciprofloxacin and resistance to ceftriaxone were each detected in 1% (1/170) of isolates. The pattern involving the greatest numbers of antimicrobials was ACSSuT-A2C-CRO-GEN-NAL.

Temporal Variations: Results are presented in Figure 15. The percentage of *E. coli* isolates with resistance to tetracycline was significantly lower in 2008 (51%, 86/170) than in 2003 (69%, 106/153), whereas the percentage with resistance to trimethoprim-sulfamethoxazole was significantly higher in 2008 (12%, 20/170) than in 2007 (4%, 8/180). There were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, 23% (39/170) of abattoir chicken *Escherichia coli* isolates were resistant to ceftriaxone. Reduced susceptibility to ciprofloxacin was detected in 3% (5/170) of isolates. Of these isolates, 1% (1/170) had reduced susceptibility to ciprofloxacin and resistance to ceftriaxone. Resistance to nalidixic acid was detected in 4% (6/170) of isolates.

FIGURE 14. Resistance to antimicrobials in *Escherichia coli* isolates from chickens; *Abattoir Surveillance*, 2008.

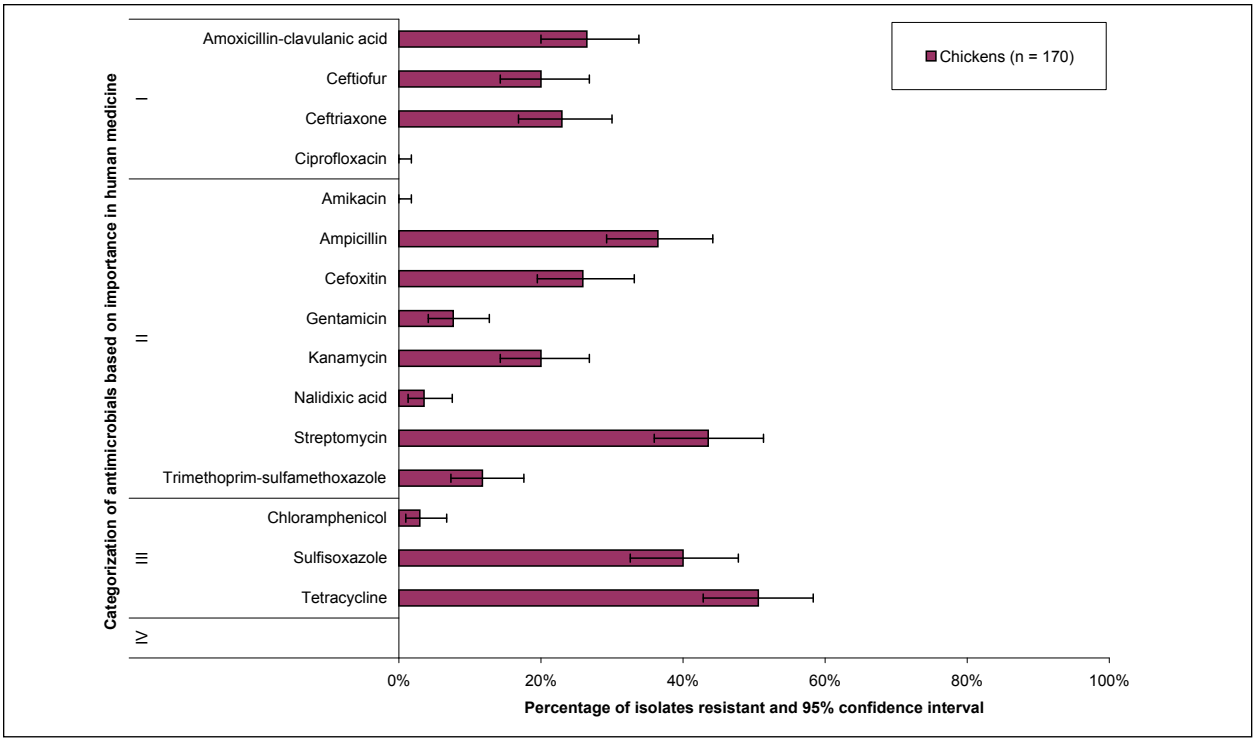
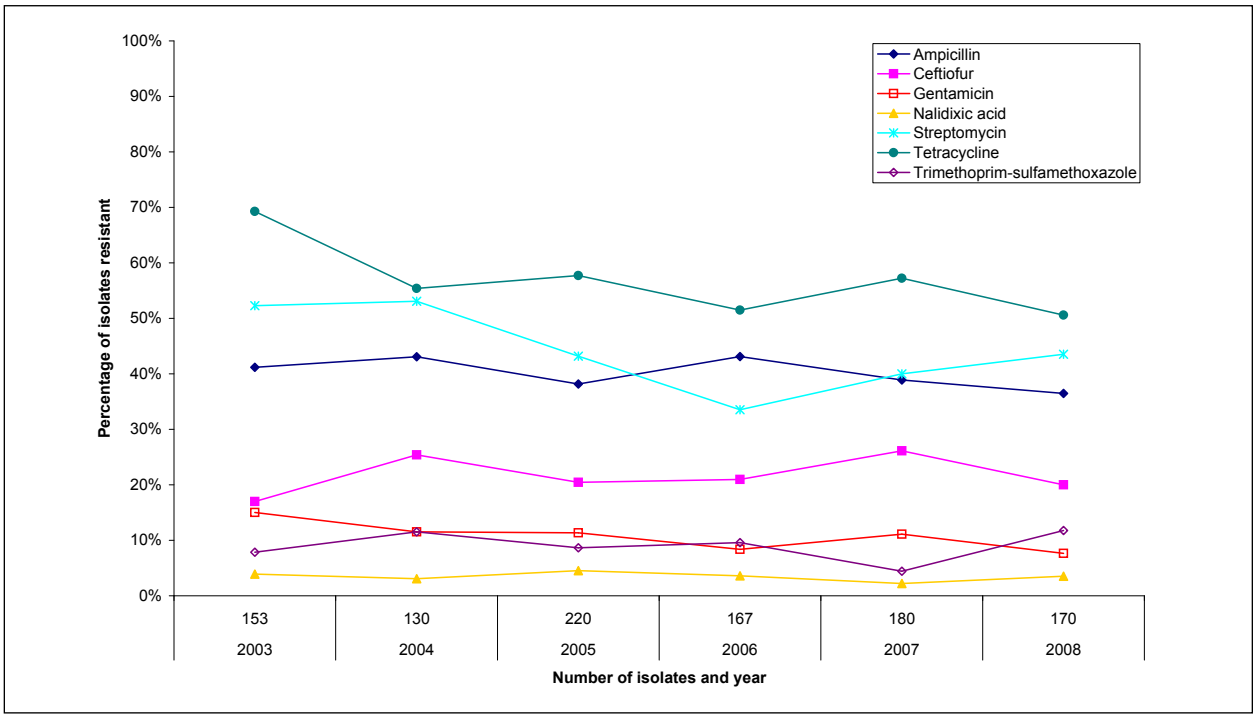


FIGURE 15. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from chickens; *Abattoir Surveillance,* 2003-2008.



Retail Meat Surveillance

(n = 479)
(British Columbia [n = 70], Saskatchewan [n = 91], Ontario [n = 150], Québec [n = 131], Maritimes region [n = 37])

Recovery: *Escherichia coli* isolates were recovered from 91% (480/526) of retail chicken samples (Table C.5, Appendix C). Province/region-specific percentages of chicken samples from which isolates were recovered were as follows: British Columbia, 90% (70/78); Saskatchewan, 99% (91/92); Ontario, 96% (150/156); Québec, 91% (131/144); and the Maritimes region, 68% (38/56). Among isolates recovered, 1 from the Maritimes region could not be re-cultured for antimicrobial susceptibility testing, resulting in a total of 37 isolates for that region.

Antimicrobial Resistance: Results are presented in Figure 16 and Table B.16, Appendix B. Resistance to amoxicillin-clavulanic acid was detected in 53% (37/70) of *E. coli* isolates from British Columbia, 21% (19/91) of isolates from Saskatchewan, 27% (41/150) of isolates from Ontario, 22% (29/131) of isolates from Québec, and 27% (10/37) of isolates from the Maritimes region. Resistance to ceftiofur was detected in 49% (34/70) of isolates from British Columbia, 20% (18/91) of isolates from Saskatchewan, 24% (36/150) of isolates from Ontario, 18% (24/131) of isolates from Québec, and 19% (7/37) of isolates from the Maritimes region. Resistance to ceftriaxone was detected in 54% (38/70) of isolates from British Columbia, 21% (19/91) of isolates from Saskatchewan, 28% (42/150) of isolates from Ontario, 21% (28/131) of isolates from Québec, and 27% (10/37) of isolates from the Maritimes region. Resistance to ciprofloxacin was detected in 1% (1/131) of isolates from Québec. Reduced susceptibility to ciprofloxacin was detected in 4% (3/70) of isolates from British Columbia, 7% (6/91) of isolates from Saskatchewan, 4% (6/150) of isolates from Ontario, and 8% (11/131) of isolates from Québec. Resistance to nalidixic acid was detected in 4% (3/70) of isolates from British Columbia, 7% (6/91) of isolates from Saskatchewan, 4% (6/150) of isolates from Ontario, and 8% (11/131) of isolates from Québec.

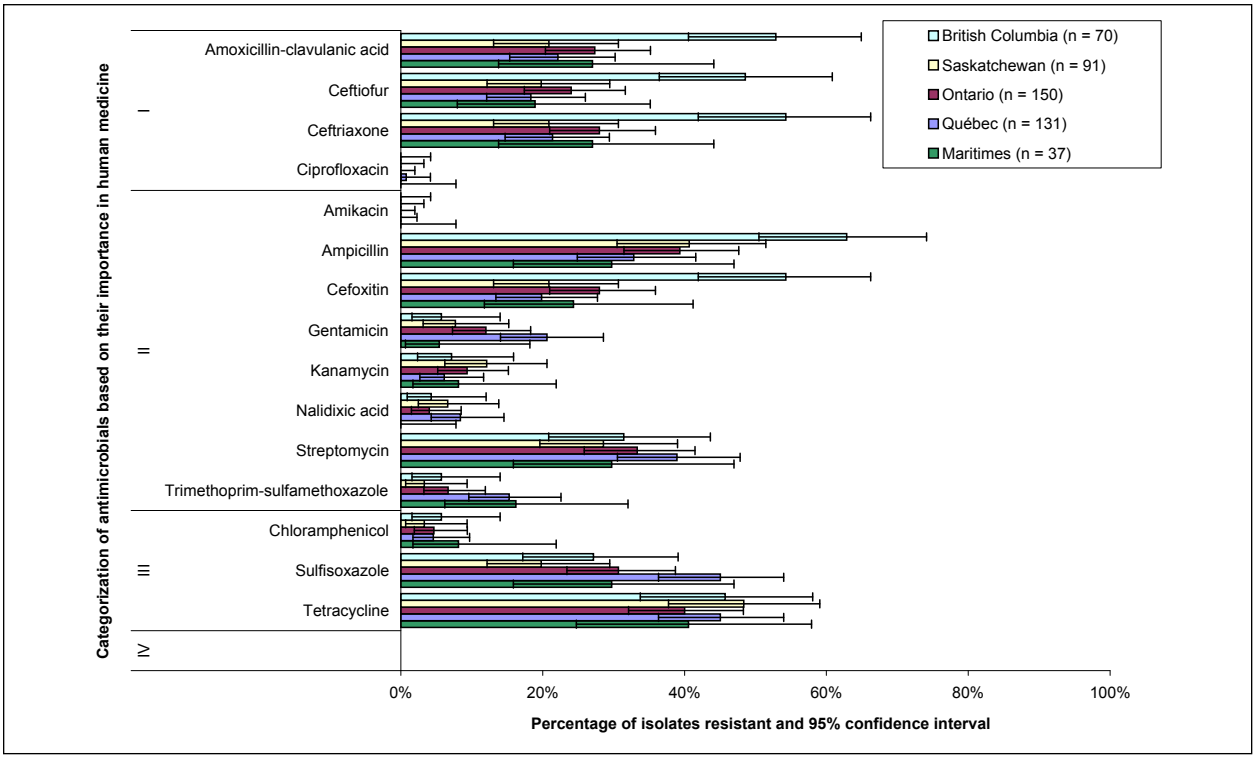
The percentages of isolates with resistance to amoxicillin-clavulanic acid and ceftriaxone were significantly higher for British Columbia than for Saskatchewan, Ontario, and Québec. The percentages of isolates from British Columbia with resistance to ceftiofur and cefoxitin were significantly higher than values for the 4 other provinces/region. The percentage of isolates from British Columbia with resistance to ampicillin was also significantly higher than values for the 4 other provinces/region. On the other hand, the percentage of isolates from Québec with resistance to gentamicin was significantly higher than that for British Columbia. The percentages of isolates from Québec with resistance to trimethoprim-sulfamethoxazole and sulfisoxazole were significantly higher than respective values for Saskatchewan. There were no significant differences among provinces/region in percentages of isolates resistant to any other antimicrobial tested. None of the isolates from any province/region were resistant to amikacin, and no isolates from the Maritimes region had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 77% (54/70) of *E. coli* isolates from British Columbia, 70% (64/91) of isolates from Saskatchewan, 69% (103/150) of isolates from Ontario, 70% (92/131) of isolates from Québec, and 62% (23/37) of isolates from the Maritimes region. Resistance to 5 or more antimicrobials was detected in 51% (36/70) of isolates from British Columbia, 22% (20/91) of isolates from Saskatchewan, 30% (45/150) of isolates from Ontario, 27% (36/131) of isolates from Québec, and 27% (10/37) of isolates from the Maritimes region. Among the isolates from all 5 provinces/region, the most common resistance patterns were A2C-AMP-CRO (10%, 46/479), TET (6%, 28/479), GEN-STR-SSS (3%, 14/479), and A2C-AMP-CRO-TET (3%, 14/479). Resistance to ceftriaxone and reduced susceptibility to ciprofloxacin were both detected in 2% (11/480) of isolates, which were received from all locations except Saskatchewan and the Maritimes region. The resistance pattern involving the greatest number of antimicrobials was ACKSSuT-A2C-CRO-GEN-NAL (1 isolate from British Columbia).

Temporal Variations: Results are presented in Figure 17. The percentages of *E. coli* isolates from Saskatchewan with resistance to ampicillin and ceftiofur were significantly higher in 2008 (40% [37/91] and 20%, respectively) than in 2005 (24% [20/82] and 4% [3/82]). The percentage of isolates from Saskatchewan with resistance to ceftiofur was significantly higher in 2008 (20%) than in both 2007 (13%, 10/75) and 2005 (4%, 3/82). The percentages of isolates from Québec with resistance to ampicillin and ceftiofur were significantly lower in 2008 (33% [43/131] and 18%, respectively) than in 2004 (52% [82/158] and 34% [54/158], respectively). The percentage of isolates from Québec with resistance to nalidixic acid was significantly higher in 2008 (8%) than in 2003 (0%, 0/111). The percentage of isolates from Québec with resistance to ceftiofur was significantly higher in 2008 (18%) than in 2006 (6%, 8/135). In the other provinces/region, there were no significant temporal variations in the percentages of isolates resistant to selected antimicrobials.

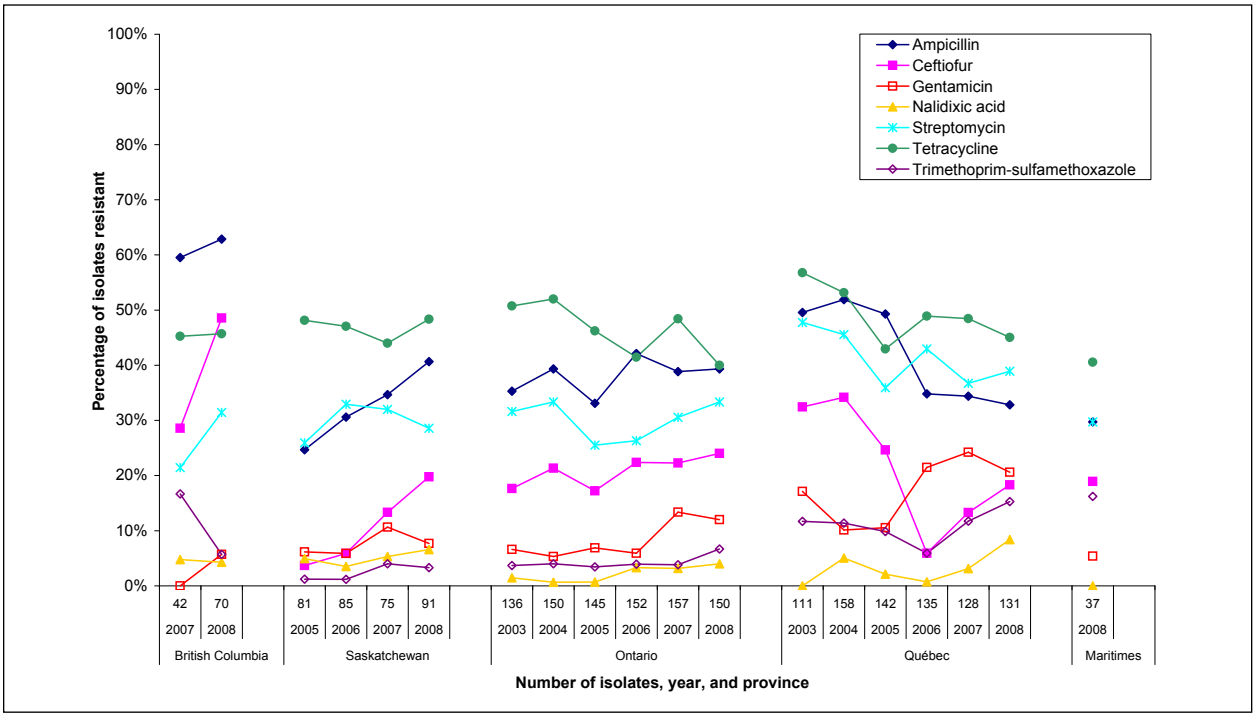
In 2008, the percentage of retail chicken *Escherichia coli* isolates with resistance to ceftriaxone was 54% (38/70) for British Columbia, 21% (19/91) for Saskatchewan, 28% (42/150) for Ontario, 21% (28/131) for Québec, and 27% (10/37) for the Maritimes region. Reduced susceptibility to ciprofloxacin was detected in 4% (3/70) of isolates from British Columbia, 7% (6/91) of isolates from Saskatchewan, 4% (6/150) of isolates from Ontario, and 9% (12/131) of isolates from Québec. The percentage of isolates from Saskatchewan with resistance to ceftiofur was significantly higher in 2008 (20%, 18/91) than in 2007 (13%, 10/75) and 2005 (4%, 3/82). The percentage of isolates from Québec with resistance to ceftiofur was significantly lower in 2008 (18%, 24/131) than in 2004 (34%, 54/158), but was was significantly higher in 2008 (18%) than in 2006 (6%, 8/135). Resistance to ceftriaxone and reduced susceptibility to ciprofloxacin were both detected in 2% (11/480) of isolates; these isolates originated from all locations except Saskatchewan and the Maritimes region.

FIGURE 16. Resistance to antimicrobials in *Escherichia coli* isolates from chicken; *Retail Meat Surveillance*, 2008.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

FIGURE 17. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from chicken; *Retail Meat Surveillance*, 2003-2008.



Retail Meat Surveillance

(n = 264)

(British Columbia [n = 50], Saskatchewan [n = 40], Ontario [n = 120], Québec [n = 54])[1]

Recovery: *Campylobacter* isolates were recovered from 29% (266/904) of retail chicken samples (Table C.5, Appendix C). Eighty-nine percent (235/265) of the isolates were *C. jejuni*, and 11% (30/265) were *C. coli*. Province-specific percentages of chicken samples from which isolates were recovered were as follows: British Columbia, 34% (50/145); Saskatchewan, 25% (41/161); Ontario, 39% (121/311); and Québec, 19% (54/287). Among those isolates recovered, 1 isolate from Saskatchewan and 1 from Ontario could not be re-cultured, leaving 40 isolates from Saskatchewan and 120 from Ontario available for antimicrobial susceptibility testing.

Antimicrobial Resistance: Results are presented in Figure 18, Figure 19, and Table B.17, Appendix B. Resistance to ciprofloxacin was detected in 8% (4/50) of *Campylobacter* isolates from British Columbia, 10% (4/40) of isolates from Saskatchewan, and 4% (5/120) of isolates from Ontario. The distribution of these ciprofloxacin-resistant isolates according to species of *Campylobacter* was as follows: *C. jejuni*, 5% (11/235); and *C. coli*, 7% (2/30). Resistance to telithromycin was detected in 4% (5/120) of isolates from Ontario and 2% (1/54) of isolates from Québec. The distribution of these telithromycin-resistant isolates according to species of *Campylobacter* was as follows: *C. jejuni*, 2% (4/234); and *C. coli*, 7% (2/30). There were no significant differences among the provinces in percentages of resistant isolates for any of the antimicrobials tested. None of the isolates were non-susceptible to florfenicol. None of the isolates from Québec were resistant to ciprofloxacin. Additionally, none of the isolates from British Columbia and Saskatchewan were resistant to telithromycin, azithromycin, clindamycin, erythromycin, or gentamicin.

Antimicrobial Resistance Patterns: Results are presented in Table 14. Resistance to 1 or more antimicrobials was detected in 36% (18/50) of *Campylobacter* isolates from British Columbia, 45% (18/40) of isolates from Saskatchewan, 53% (63/120) of isolates from Ontario, and 56% (30/54) of isolates from Québec. Resistance to 3 or more antimicrobials was detected in 4% (2/50) of isolates from British Columbia, 10% (4/40) of isolates from Saskatchewan, 10% (12/120) of isolates from Ontario, and 11% (6/54) of isolates from Québec. Among the isolates from all 4 provinces, the most common resistance patterns were TET (38%, 101/264), AZM-ERY-TET (3%, 9/264), and CIP-NAL-TET (3%, 9/264). The resistance pattern involving the greatest number of antimicrobials among the isolates was AZM-CIP-CLI-ERY-NAL-TEL-TET (1 *C. jejuni* isolate from Ontario).

Temporal Variations: Results are presented in Figure 20. The percentage of *Campylobacter* isolates from Ontario with resistance to azithromycin was significantly higher in 2008 (8%, 10/120) than in 2007 (2%, 2/117). For the other provinces, there were no significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, the percentage of retail chicken *Campylobacter* isolates with resistance to ciprofloxacin was 8% (4/50) for British Columbia, 10% (4/40) for Saskatchewan, and 4% (5/120) for Ontario. Among the isolates from all 4 provinces, the most common resistance patterns were TET (38%, 101/264), AZM-ERY-TET (3%, 9/264), and CIP-NAL-TET (3%, 9/264). The percentage of *Campylobacter* isolates from Ontario with resistance to azithromycin was significantly higher in 2008 (8%, 10/120) than in 2007 (2%, 2/117). The resistance pattern involving the greatest number of antimicrobials among the isolates was AZM-CIP-CLI-ERY-NAL-TEL-TET (1 *C. jejuni* isolate from Ontario).

[1] Isolates recovered from retail chicken in the Maritimes region underwent antimicrobial susceptibility testing, but results are not presented in this report because of concerns regarding harmonization of laboratory methods for 2008 only.

FIGURE 18. Resistance to antimicrobials in *Campylobacter* isolates from chicken; *Retail Meat Surveillance*, 2008.

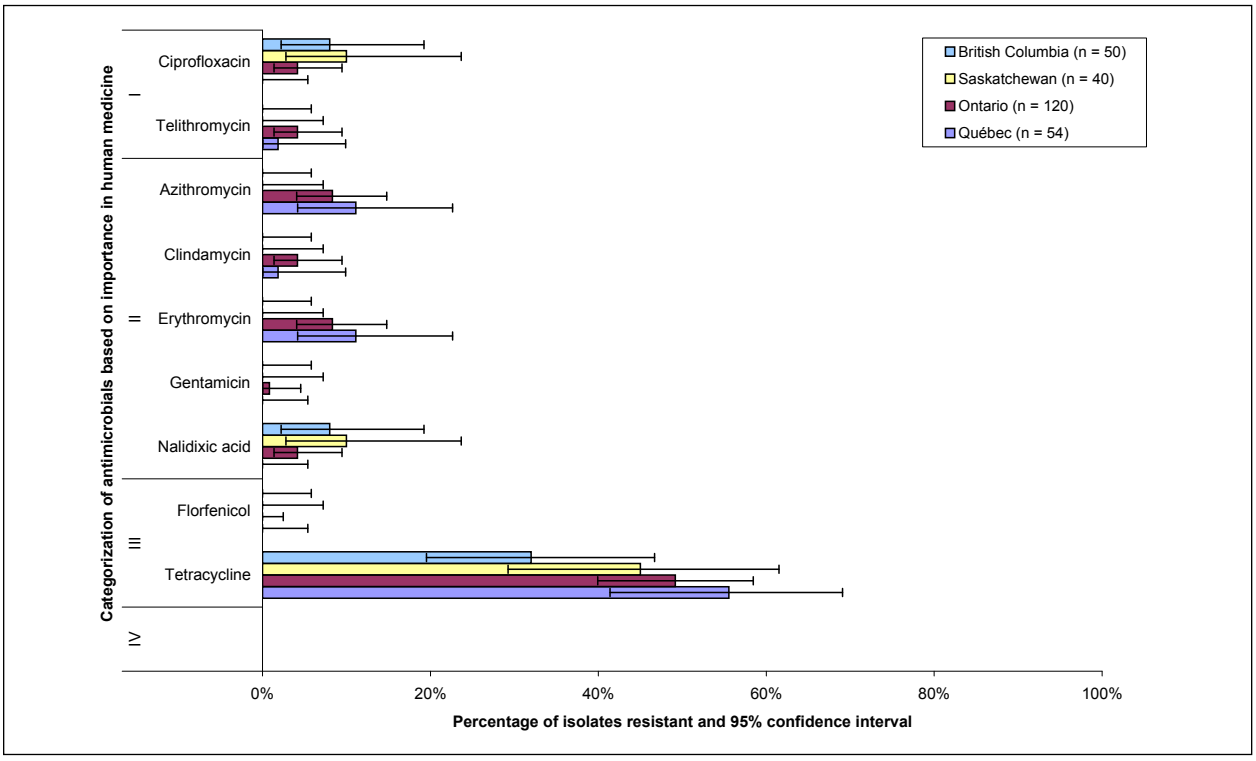


FIGURE 19. Resistance to antimicrobials in *Campylobacter* isolates from chicken, by *Campylobacter* species; *Retail Meat Surveillance*, 2008.

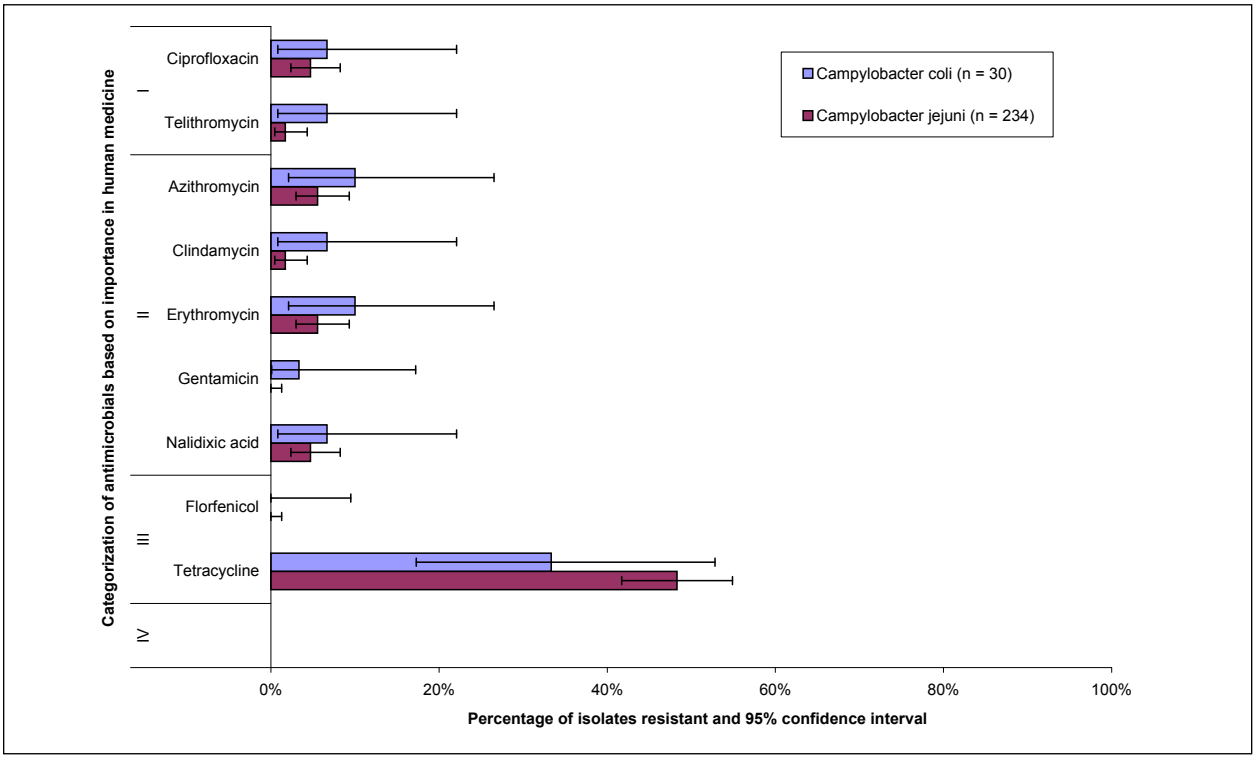
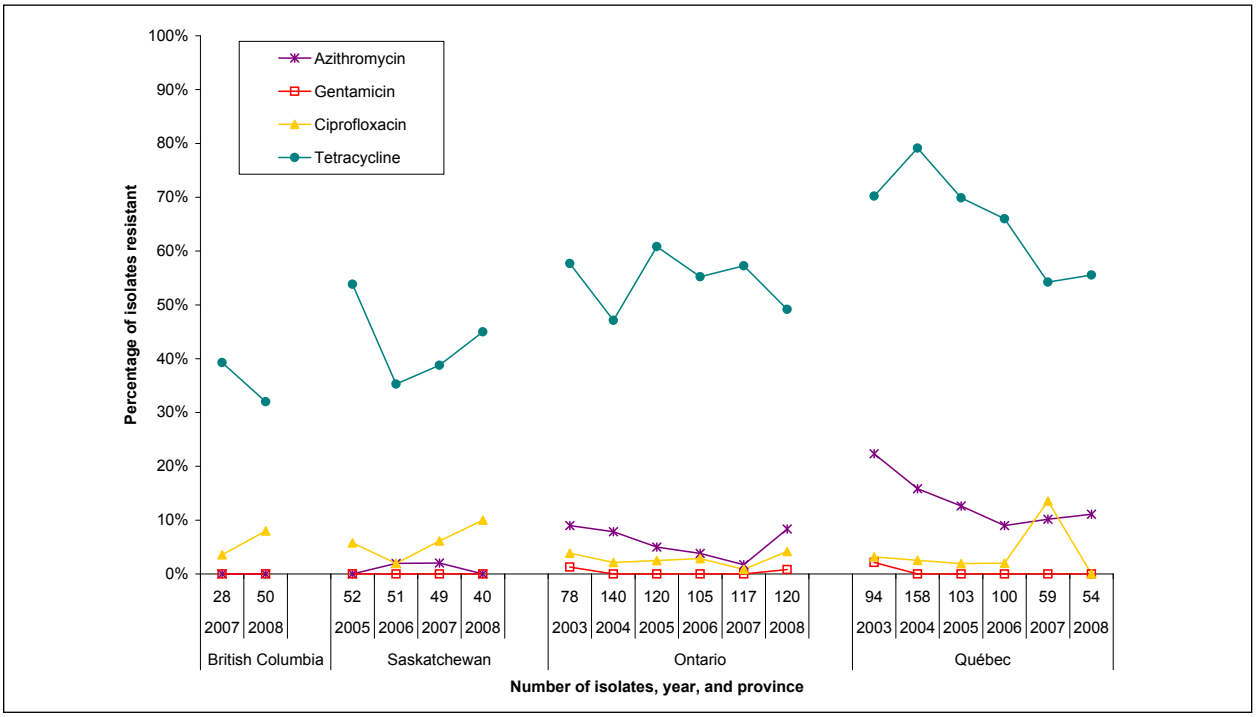


TABLE 14. Number of antimicrobials in resistance patterns of *Campylobacter* isolates from chicken, by province and *Campylobacter* species; *Retail Meat Surveillance*, 2008.

Species	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 2	3 - 4	5 - 9
		Number of isolates			
British Columbia					
C. jejuni	44 (88.0)	28	15	1	0
C. coli	6 (12.0)	4	1	1	0
Total	50 (100)	32	16	2	0
Saskatchewan					
C. jejuni	37 (92.5)	19	14	4	0
C. coli	3 (7.5)	3	0	0	0
Total	40 (100)	22	14	4	0
Ontario					
C. jejuni	104 (86.7)	49	46	8	1
C. coli	16 (13.3)	8	5	1	2
Total	120 (100)	57	51	9	3
Québec					
C. jejuni	49 (90.7)	20	23	5	1
C. coli	5 (9.3)	4	1	0	0
Total	54 (100)	24	24	5	1
Total	**264 (100)**	**135**	**105**	**20**	**4**

FIGURE 20. Temporal variation in resistance to selected antimicrobials in *Campylobacter* isolates from chicken; *Retail Meat Surveillance*, 2003-2008.



Retail Meat Surveillance

(n = 464)

(British Columbia [n = 77], Saskatchewan [n = 91], Ontario [n = 154], Québec [n = 142])[1]

Recovery: *Enterococcus* isolates were recovered from 99.6% (468/470) of retail chicken samples (Table C.5, Appendix C). Four isolates could not be cultured after freezing, leaving 464 isolates available for antimicrobial susceptibility testing. Ninety-four percent (436/464) of the remaining isolates were *E. faecalis*, 3% (16/464) were other *Enterococcus* spp., and 3% (12/464) were *E. faecium*. Province-specific percentages of chicken samples from which *Enterococcus* was recovered were as follows: British Columbia, 100% (78/78); Saskatchewan, 100% (92/92); Ontario, 99% (154/156); and Québec, 100% (144/144).

Antimicrobial Resistance: Results are presented in Figure 21, Figure 22, and Table B.18, Appendix B. Resistance to ciprofloxacin was detected in 1% (1/91) of *Enterococcus* isolates from Saskatchewan, 3% (4/154) of isolates from Ontario, and 1% (1/142) of isolates from Québec. Three of the 12 *E. faecium* isolates and 1% (3/436) of *E. faecalis* isolates were resistant to ciprofloxacin. Resistance to tigecycline was detected in 1% (1/142) of *E. faecalis* isolates from Québec. There were no significant differences among provinces in percentages of isolates that were resistant to any antimicrobials. Resistance to ciprofloxacin was not detected in isolates from British Columbia. None of the isolates from any province were resistant to linezolid or vancomycin or were non-susceptible to daptomycin.

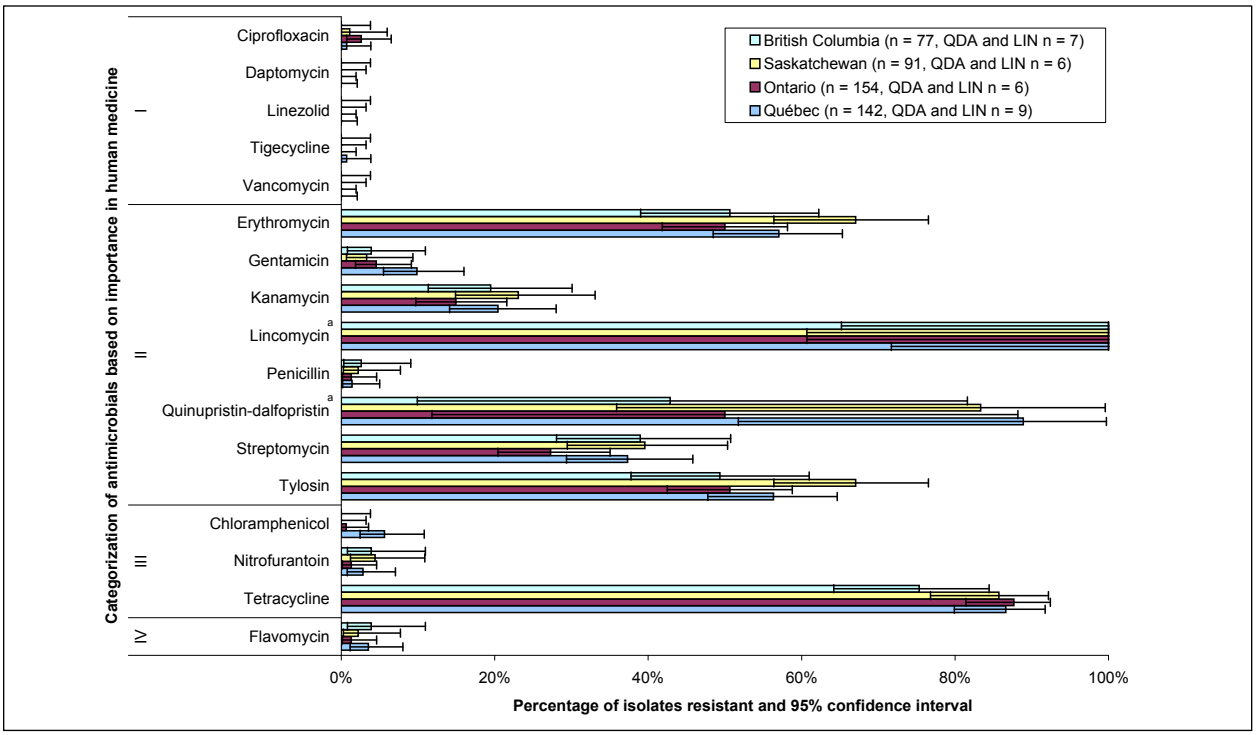
Antimicrobial Resistance Patterns: Results are presented in Table 15. Resistance to 1 or more antimicrobials was detected in 96% (74/77) of *Enterococcus* isolates from British Columbia, 88% (85/91) of isolates from Saskatchewan, 92% (142/154) of isolates from Ontario, and 89% (127/142) of isolates from Québec. Resistance to 5 or more antimicrobials was detected in 18% (14/77) of isolates from British Columbia, 22% (20/91) of isolates from Saskatchewan, 16% (25/154) of isolates from Ontario, and 25% (36/142) of isolates from Québec. Among the isolates from all 4 provinces, the most common resistance patterns were TET (27%, 127/464), ERY-TET-TYL (19%, 89/464), and ERY-STR-TET-TYL (11%, 50/464). The resistance pattern involving the greatest number of antimicrobials among isolates was ERY-LIN-NIT-PEN-STR-QDA-TET-TYL (1 *E. faecium* isolate from Saskatchewan).

Temporal Variations: Results are presented in Figure 23. The percentages of *Enterococcus* isolates from Saskatchewan with resistance to erythromycin, streptomycin, and tylosin were significantly higher in 2008 (67% [61/91], 40% [36/91], and 67% [61/91], respectively) than in 2005 (39% [31/80], 20% [16/80], and 40% [32/80], respectively). The percentages of isolates from Saskatchewan with resistance to erythromycin and tylosin were significantly higher in 2008 (67% each) than in 2007 (46% [35/76] each). The percentage of isolates from Ontario with resistance to tylosin was significantly higher in 2008 (51%, 78/154) than in 2007 (39%, 63/161). For the other provinces, there were no significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, resistance to ciprofloxacin was detected in retail chicken *Enterococcus* isolates from Saskatchewan (1%, 1/91), Ontario (3%, 4/154), and Québec (1%, 1/142). The percentages of isolates from Saskatchewan with resistance to erythromycin, streptomycin, and tylosin were significantly higher in 2008 (67% [61/91], 40% [36/91], and 67% [61/91], respectively) than in 2005 (39% [31/80], 20% [16/80], and 40% [32/80], respectively), The percentages of isolates with resistance to erythromycin and tylosin were significantly higher in 2008 (67% each) than in 2007 (46% [35/76] each). The percentage of isolates from Ontario with resistance to tylosin was significantly higher in 2008 (51%, 78/154) than in 2007 (39%, 63/161).

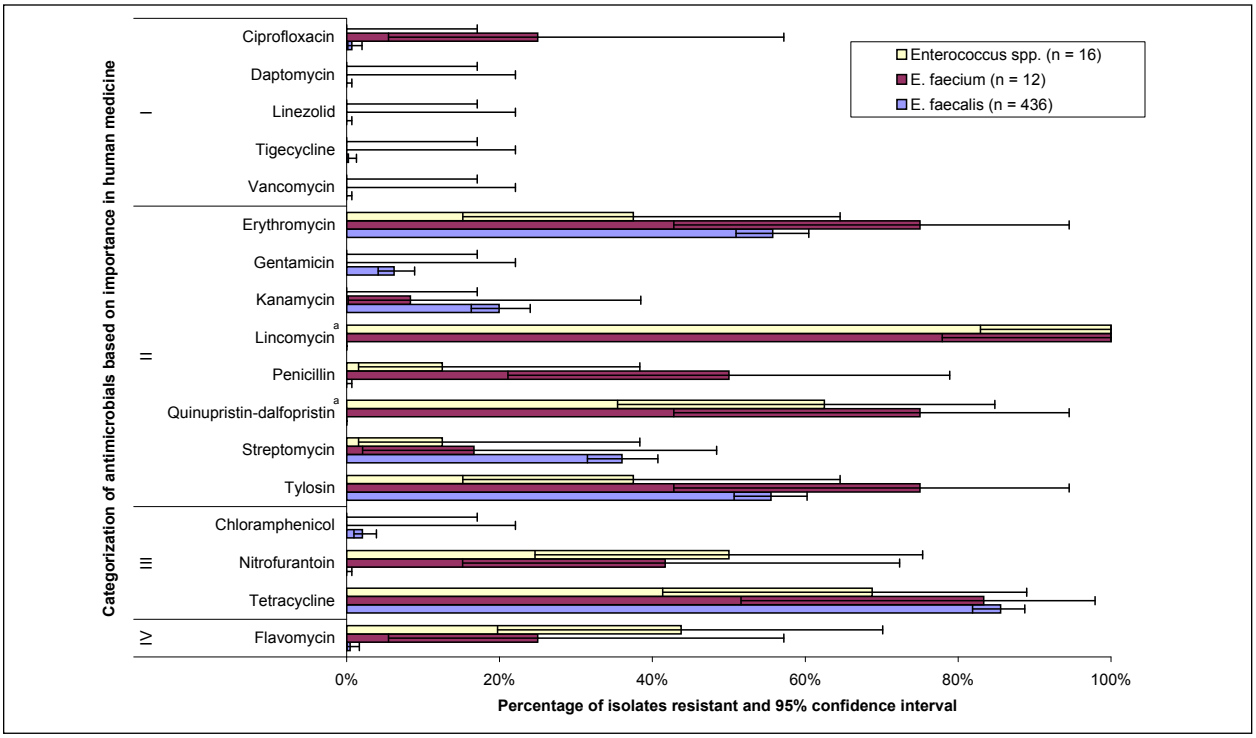
[1] Isolates recovered from retail chicken in the Maritimes region underwent antimicrobial susceptibility testing but results are not presented in this report because of concerns surrounding harmonization of laboratory methods for 2008 only.

FIGURE 21. Resistance to antimicrobials in *Enterococcus* isolates from chicken, by province; *Retail Meat Surveillance*, 2008.



[a] Resistance to quinupristin-dalfopristin (QDA) and lincomycin (LIN) is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

FIGURE 22. Resistance to antimicrobials in *Enterococcus* isolates from chicken, by *Enterococcus* species; *Retail Meat Surveillance*, 2008.

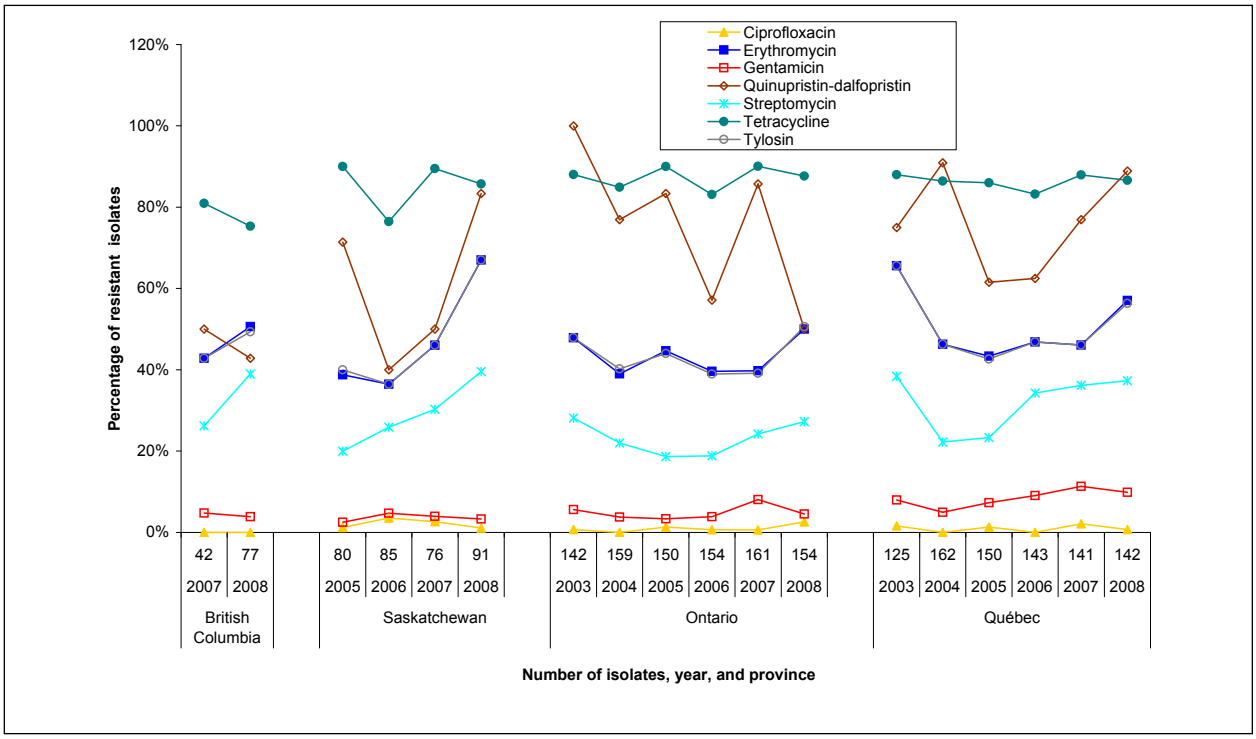


[a] Resistance to quinupristin-dalfopristin and lincomycin is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

TABLE 15. Number of antimicrobials in resistance patterns of *Enterococcus* isolates from chicken, by *Enterococcus* species; *Retail Meat Surveillance*, 2008.

Species	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 17
		Number of isolates			
British Columbia					
E. faecalis	70 (90.9)	3	55	12	0
Enterococcus spp.	4 (5.2)	0	3	1	0
E. faecium	3 (3.9)	0	2	1	0
Total	77 (100)	3	60	14	0
Saskatchewan					
E. faecalis	85 (93.4)	6	62	17	0
Enterococcus spp.	5 (5.5)	0	3	2	0
E. faecium	1 (1.1)	0	0	1	0
Total	91 (100)	6	65	20	0
Ontario					
E. faecalis	148 (96.1)	12	114	22	0
E. faecium	3 (1.9)	0	0	3	0
Enterococcus spp.	3 (1.9)	0	3	0	0
Total	154 (100)	12	117	25	0
Québec					
E. faecalis	133 (93.7)	15	90	28	0
E. faecium	5 (3.5)	0	1	4	0
Enterococcus spp.	4 (2.8)	0	0	4	0
Total	142 (100)	15	91	36	0
Total	**464 (100)**	**36**	**333**	**95**	**0**

FIGURE 23. Temporal variation in resistance to selected antimicrobials in *Enterococcus* isolates from chicken; *Retail Meat Surveillance*, 2003-2008.



The annual number of isolates tested for quinupristin-dalfopristin per province is generally below 10 because *Enterococcus faecalis* isolates had to be excluded from the analysis because of their intrinsic resistance to this antimicrobial.

Salmonella

Farm Surveillance[1]

(n = 61)

Recovery: *Salmonella* isolates were recovered from 13% (61/486) of pig fecal samples.

Serovars: Results are presented in Table 16 and Table C.2, Appendix C. The most common *Salmonella* serovars were Typhimurium var. 5- (28%, 17/61), Brandenburg (15%, 9/61), Bovismorbificans (11%, 7/61), and Derby (11%, 7/61). These 4 serovars accounted for 66% (40/61) of the isolates.

Antimicrobial Resistance: Results are presented in Figure 24 and Table B.19, Appendix B. None of the isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, or nalidixic acid. In addition, none of the *Salmonella* isolates had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 16 and Table C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 62% (38/61) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 23% (14/61). The most common resistance patterns were ACKSSuT (15%, 9/61), STR-SSS-TET (11%, 7/61), and TET (10%, 6/61). The pattern involving the greatest number of antimicrobials among isolates was AKSSuT-GEN-SXT (1 *S.* Ohio var. 14+).

Temporal Variations: Results are presented in Figure 25. Between 2007 and 2008, there were no significant temporal variations in the percentages of *Salmonella* isolates resistant to the selected antimicrobials.

In 2008, none of the farm pig *Salmonella* isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, or nalidixic acid or had reduced susceptibility to ciprofloxacin.

[1] The percentages provided in the text and in the figures and tables were adjusted to account for clustering within herds, whereas proportions represent unadjusted values (see Appendix A).

FIGURE 24. Resistance to antimicrobials in *Salmonella* isolates from pigs; *Farm Surveillance*, 2008.

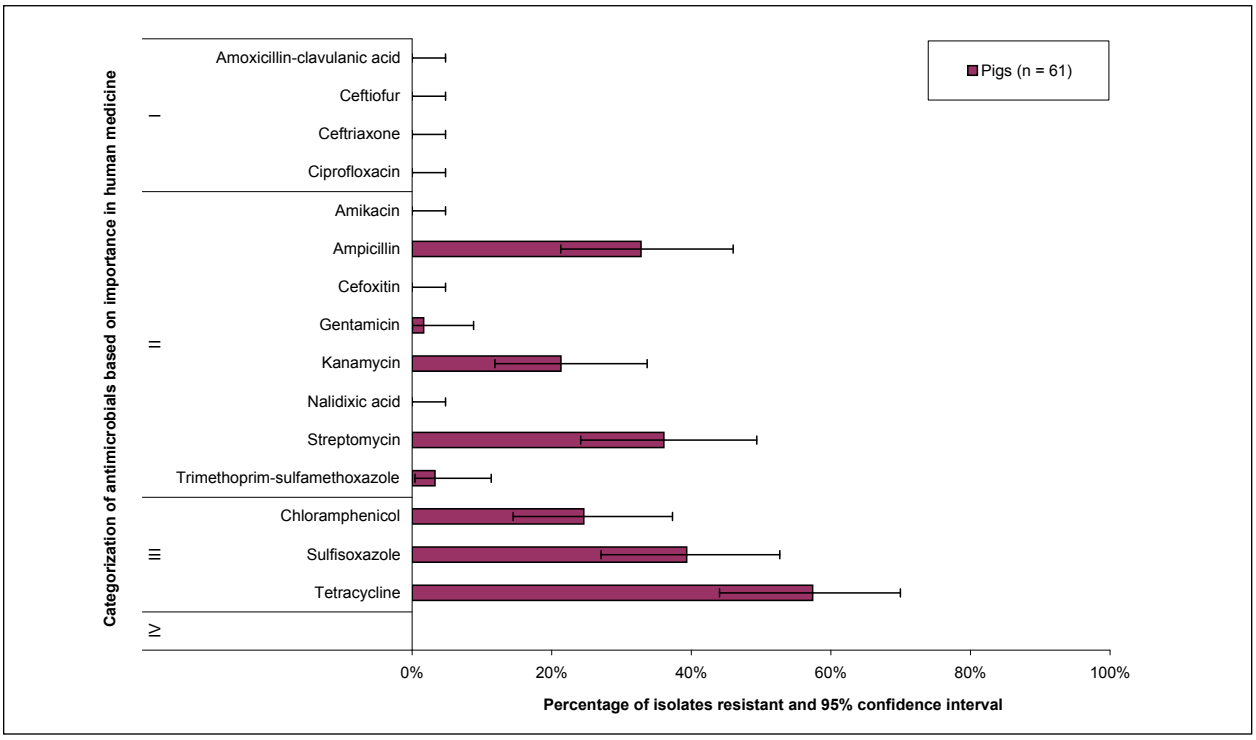
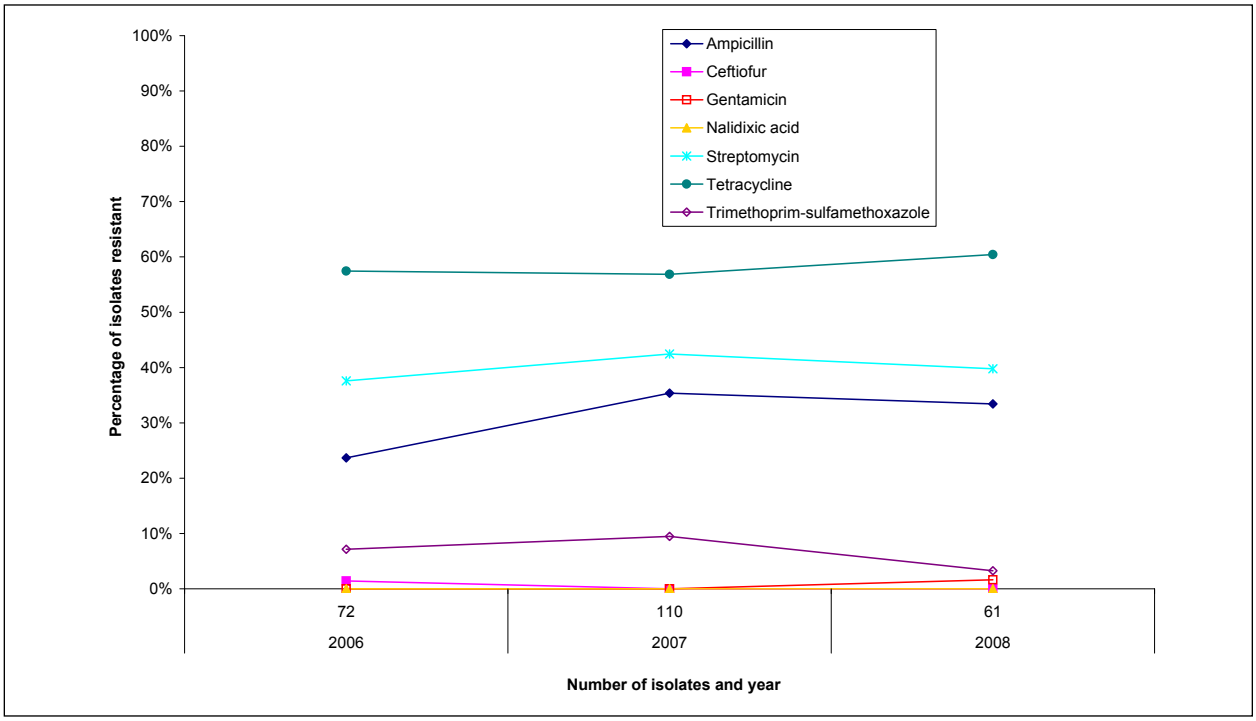


TABLE 16. Number of antimicrobials in resistance patterns of *Salmonella* isolates from pigs, by serovar; *Farm Surveillance*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Typhimurium var. 5-	17 (27.9)	5	4	8	0
Brandenburg	9 (14.8)	0	9	0	0
Bovismorbificans	7 (11.5)	5	2	0	0
Derby	7 (11.5)	0	7	0	0
Mbandaka	4 (6.6)	2	2	0	0
Typhimurium	3 (4.9)	0	0	3	0
I 4,[5],12:i:-	2 (3.3)	1	0	1	0
Infantis	2 (3.3)	2	0	0	0
London	2 (3.3)	2	0	0	0
Less common serovars	8 (13.1)	6	0	2	0
Total	**61 (100)**	**23**	**24**	**14**	**0**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

FIGURE 25. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from pigs; *Farm Surveillance*, 2006-2008.



Abattoir Surveillance

(n = 151)

Recovery: *Salmonella* isolates were recovered from 44% (151/340) of pig caecal samples (Table C.5, Appendix C).

Serovars: Results are presented in Table 17 and Table C.2, Appendix C. The most common *Salmonella* serovars were Derby (22%, 33/151), Typhimurium var. 5- (21%, 31/151), and Typhimurium (11%, 17/151). These 3 serovars accounted for 54% (81/151) of the isolates.

Antimicrobial Resistance: Results are presented in Figure 26 and Table B.20, Appendix B. One percent (2/151) of *Salmonella* isolates were resistant to amoxicillin-clavulanic acid. Resistance to ceftiofur and resistance to ceftriaxone were each detected in 1% (1/151). None of the isolates were resistant to ciprofloxacin, amikacin, or nalidixic acid. None had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 17 and Table C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 64% (96/151) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 24% (36/151) of the isolates (including 22 *S.* Typhimurium var. 5- and 10 *S.* Typhimurium). The most common resistance patterns were TET (15%, 22/151), STR-SSS-TET (13%, 19/151), ACSSuT (13%, 19/151), and ACKSSuT (6%, 9/151). The patterns involving the greatest number of antimicrobials were A2C-AMP-CRO-STR-TET (1 *S.* Anatum) and ACKSSuT-SXT (1 *S.* Typhimurium and 1 *S.* Typhimurium var. 5-).

Temporal Variations: Results are presented in Figure 27. Percentages of isolates with resistance to ampicillin, streptomycin, trimethoprim-sulfamethoxazole, and tetracycline were significantly higher in 2008 (28% [42/151], 44% [67/151], 7% [10/151], and 58% [87/151], respectively) than in 2003 (18% [70/391], 34% [132/391], 2% [9/391], and 45% [176/391] respectively). However, the percentage of isolates with resistance to gentamicin was significantly lower in 2008 (1%, 1/151) than in 2007 (6%, 6/105).

In 2008, 1% (2/151) of abattoir pig *Salmonella* isolates were resistant to amoxicillin-clavulanic acid. Resistance to ceftiofur and ceftriaxone were each detected in 1% (1/151) of isolates. The percentages of *Salmonella* isolates with resistance to ampicillin, streptomycin, trimethoprim-sulfamethoxazole, and tetracycline were significantly higher in 2008 (28% [42/151], 44% [67/151], 7% [10/151], and 58% [87/151], respectively) than in 2003 (18% [69/391], 34% [132/391], 2% [9/391], and 45% [176/391], respectively). The percentage of isolates with resistance to gentamicin was significantly lower in 2008 (1%, 1/151) than in 2007 (6%, 6/105).

FIGURE 26. Resistance to antimicrobials in *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2008.

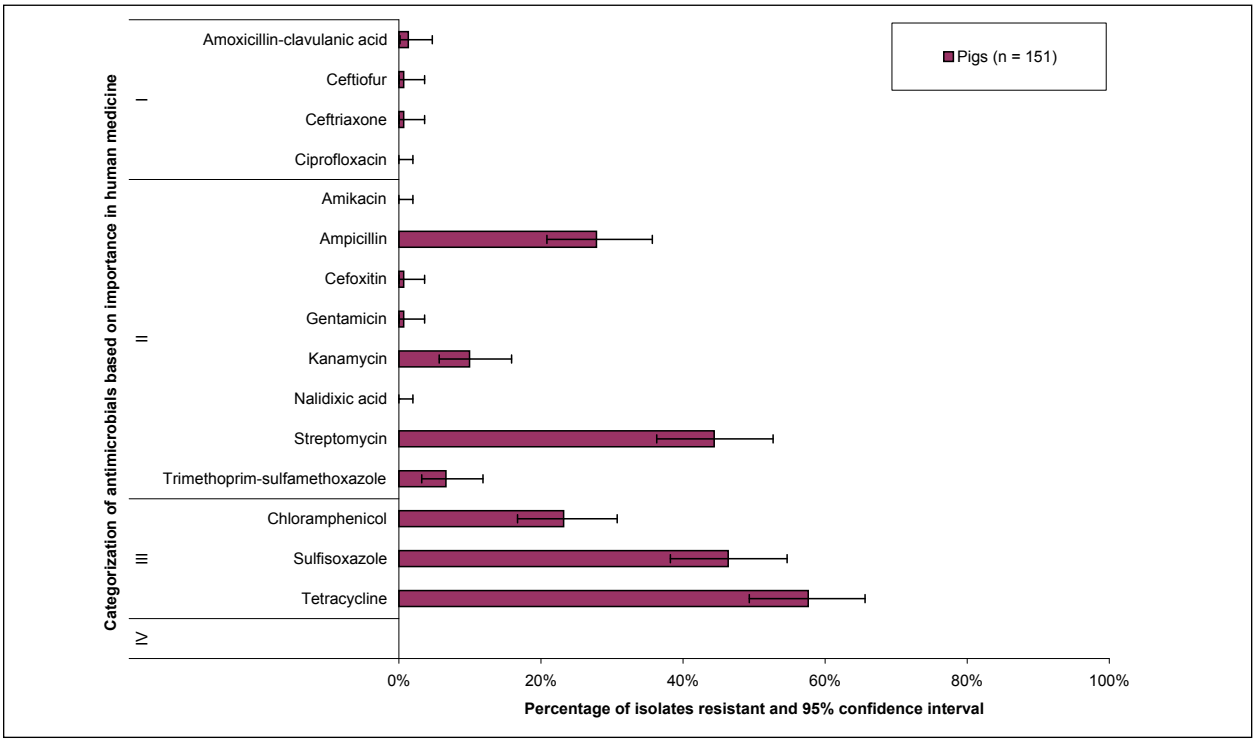
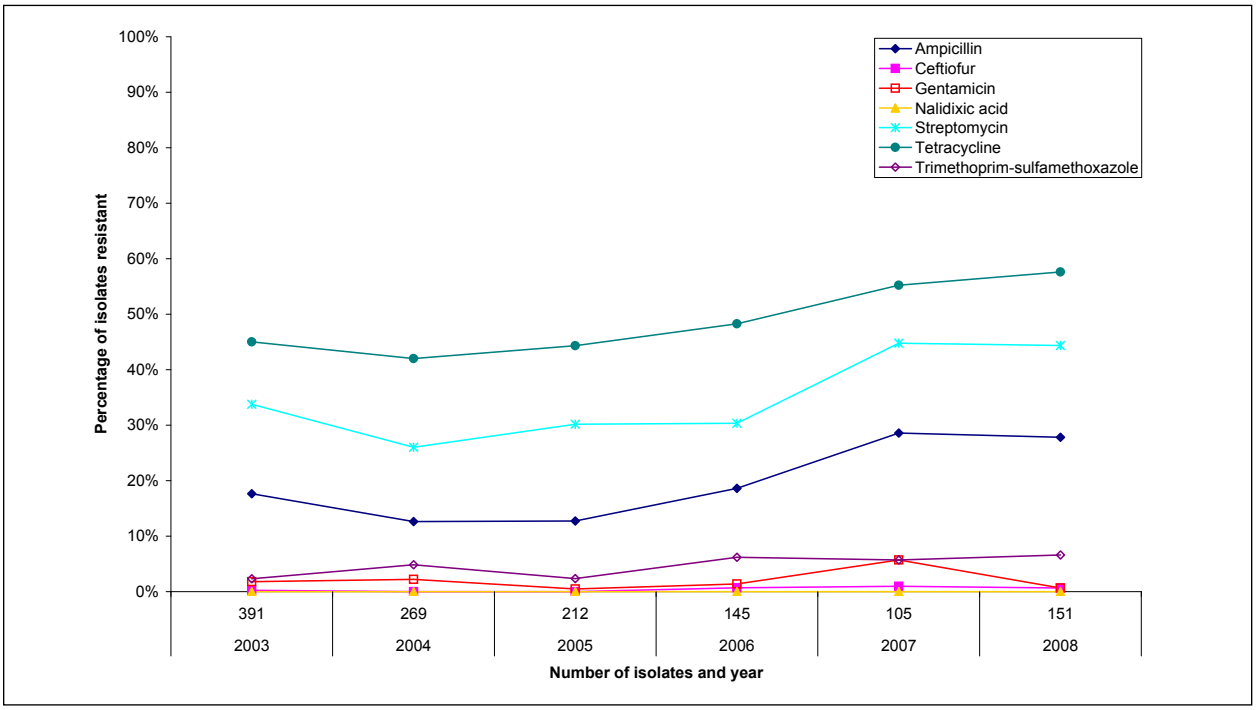


TABLE 17. Number of antimicrobials in resistance patterns of *Salmonella* isolates from pigs, by serovar; *Abattoir Surveillance*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Derby	33 (21.9)	4	28	1	0
Typhimurium var. 5-	31 (20.5)	1	8	22	0
Typhimurium	17 (11.3)	2	5	10	0
Brandenburg	10 (6.6)	4	6	0	0
Infantis	8 (5.3)	7	1	0	0
Worthington	7 (4.6)	1	6	0	0
Uganda	6 (4.0)	6	0	0	0
Give	5 (3.3)	4	1	0	0
Ohio	5 (3.3)	2	1	2	0
Bovismorbificans	4 (2.6)	4	0	0	0
Mbandaka	4 (2.6)	4	0	0	0
Less common serovars	21 (13.9)	16	4	1	0
Total	**151 (100)**	**55**	**60**	**36**	**0**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

FIGURE 27. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2003-2008.



Retail Meat Surveillance, 2003-2008[1]

(n = 36)

(British Columbia [n = 4], Saskatchewan [n = 7], Ontario [n = 14], Québec [n = 9], Maritimes region [n = 2])

Recovery: From 2003 to 2008, inclusive, *Salmonella* isolates were recovered from 1% (37/2,612) of retail pork samples (Table C.5, Appendix C).[2] Province/region-specific percentages of pork samples from which isolates were recovered were as follows: British Columbia, 2% (4/244); Saskatchewan, 2% (7/464); Ontario, 2% (15/978); Québec, 1% (9/840); and the Maritimes region, 2% (2/86). In 2003, 1 Ontario isolate did not grow after freezing and could not be submitted for serotyping and antimicrobial susceptibility testing. Because of the low number of isolates per province/region, data have been combined and presented for the entire 2003-2008 period for all provinces/region.

Serovars: Results are presented in Table 18 and Table C.2, Appendix C. The most common *Salmonella* serovars recovered from retail pork were Typhimurium (19%, 7/36), Derby (11%, 4/36), Typhimurium var. 5- (11%, 4/36), Heidelberg (8%, 3/36), Johannesburg (8%, 3/36), and Kentucky (8%, 3/36). All Johannesburg isolates were from Saskatchewan. Five of 7 *S.* Typhimurium isolates and 3 of 4 *S.* Typhimurium var. 5- isolates were from Ontario.

Antimicrobial Resistance: Results are presented in Figure 28 and Table B.21. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 1 *S.* Kentucky isolate from Québec. None of the isolates from the 5 provinces/region were resistant to ciprofloxacin, amikacin, gentamicin, or nalidixic acid. None of the isolates had reduced susceptibility to ciprofloxacin.

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1 Because of the low prevalence of *Salmonella* detected in pork, antimicrobial susceptibility results for the few isolates recovered each year are not presented on an annual basis. Rather, 6 years of results have been pooled together and are presented here.

2 Because few isolates were recovered in 2003 (2%, 2/125), testing was stopped in 2004 and 2005. However, given increasing concern and interest associated with *Salmonella* in pork, testing was reinitiated in 2006. In 2007, a new method of isolate recovery was implemented for all retail meat samples. For a summary of recovery by year and province, see Table C.5, Appendix C.

Antimicrobial Resistance Patterns: Results are presented in Table 18 and Table B.21, Appendix B. Resistance to 1 or more antimicrobials was detected in 69% (25/36) of *Salmonella* isolates from retail pork (3 from British Columbia, 6 from Saskatchewan, 8 from Ontario, 6 from Québec, and 2 from the Maritimes region). Resistance to 5 or more antimicrobials was detected in 17% (6/36) of isolates (3 *S.* Typhimurium and 2 *S.* Typhimurium var. 5- from Ontario and 1 *S.* Kentucky from Québec). Among isolates from all 5 provinces/region, the most common resistance patterns were TET (8%, 3/36), STR-TET (8%, 3/36), STR-SSS-TET (8%, 3/36), CHL-STR-SSS-TET (8%, 3/36), ACSSuT (8%, 3/36), and AMP (6%, 2/36). The isolates with the ACSSuT resistance pattern were all from Ontario (2 *S.* Typhimurium and 1 *S.* Typhimurium var. 5-). The pattern involving the greatest number of antimicrobials was A2C-AMP-CRO-STR, which was detected in 1 *S.* Kentucky isolate from Québec in 2007.

From 2003 to 2008, *Salmonella* was recovered from 1% of retail pork samples. One isolate of *S.* Kentucky recovered from Québec retail pork in 2007 was resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ampicillin, cefoxitin, and streptomycin. No other isolates were resistant to any Category I antimicrobials. Three isolates from Ontario (2 *S.* Typhimurium and 1 *S.* Typhimurium var. 5-) had the ACSSuT resistance pattern.

FIGURE 28. Resistance to antimicrobials in *Salmonella* isolates from pork; *Retail Meat Surveillance*, 2003-2008.

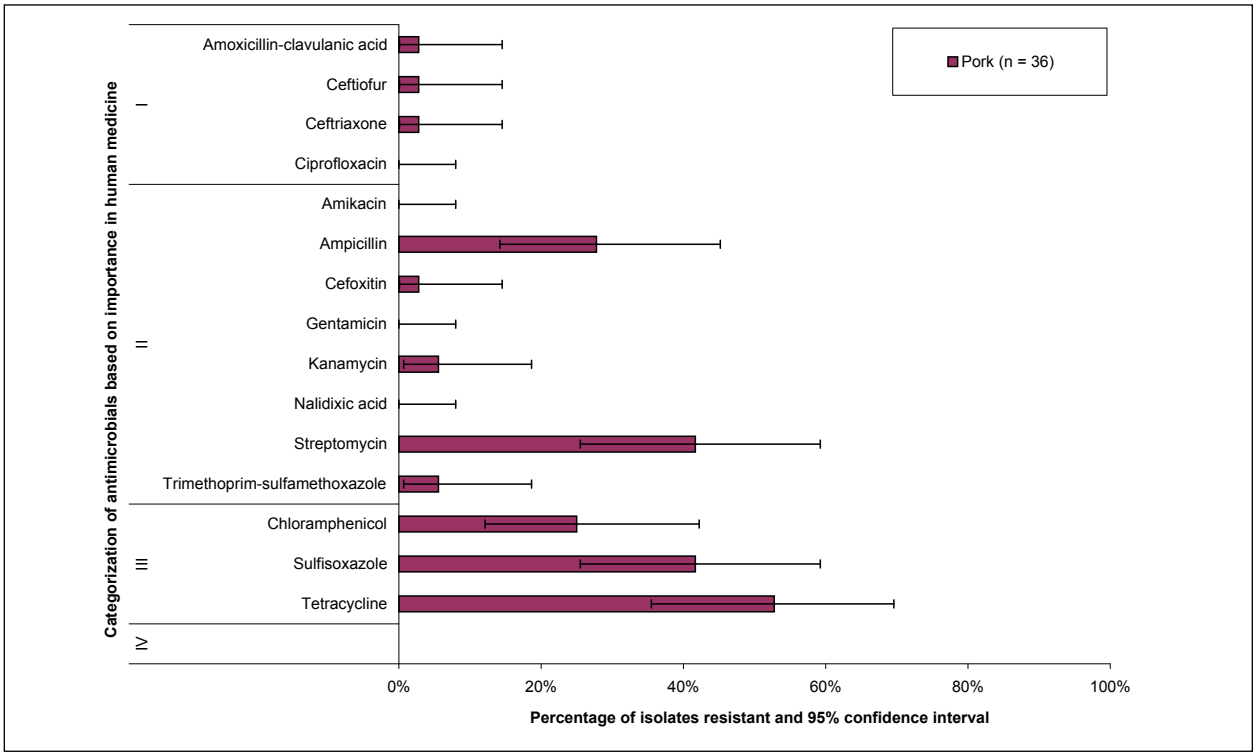


TABLE 18. Number of antimicrobials in resistance patterns of *Salmonella* isolates from pork, by serovar; *Retail Meat Surveillance*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
British Columbia					
Derby	1 (25.0)	0	1	0	0
Give	1 (25.0)	1	0	0	0
Kentucky	1 (25.0)	0	1	0	0
London	1 (25.0)	0	1	0	0
Total	4 (100)	1	3	0	0
Saskatchewan					
Johannesburg	3 (42.9)	0	3	0	0
Derby	1 (14.3)	0	1	0	0
I 40:-:enx	1 (14.3)	0	1	0	0
Ohio	1 (14.3)	1	0	0	0
Schwarzengrund	1 (14.3)	0	1	0	0
Total	7 (100)	1	6	0	0
Ontario					
Typhimurium	5 (35.7)	1	1	3	0
Typhimurium var. 5-	3 (21.4)	1	0	2	0
Derby	1 (7.1)	1	0	0	0
Enteritidis	1 (7.1)	1	0	0	0
Heidelberg	1 (7.1)	0	1	0	0
I Rough:z10:-	1 (7.1)	1	0	0	0
Kentucky	1 (7.1)	0	1	0	0
Krefeld	1 (7.1)	1	0	0	0
Total	14 (100)	6	3	5	0
Québec					
Heidelberg	2 (22.2)	1	1	0	0
Agona	1 (11.1)	0	1	0	0
Berta	1 (11.1)	1	0	0	0
Derby	1 (11.1)	0	1	0	0
I 4,[5],12:i:-	1 (11.1)	1	0	0	0
Kentucky	1 (11.1)	0	0	1	0
Typhimurium	1 (11.1)	0	1	0	0
Typhimurium var. 5-	1 (11.1)	0	1	0	0
Total	9 (100)	3	5	1	0
Maritimes					
Typhimurium	1 (50.0)	0	1	0	0
Vi:Rough:-:-	1 (50.0)	0	1	0	0
Total	2 (100)	0	2	0	0
Total	**36 (100)**	**11**	**19**	**6**	**0**

The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Surveillance of Animal Clinical Isolates[1]

(n = 158)

Serovars: Results are presented in Table 19 and Table C.2, Appendix C. The most common *Salmonella* serovars in pig clinical isolates were Typhimurium (39%, 61/158), Typhimurium var. 5- (17%, 27/158), and Derby (9%, 15/158). These 3 serovars accounted for 65% (103/158) of *Salmonella* isolates.

Antimicrobial Resistance: Results are presented in Table B.22, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 1% (2/158) of *Salmonella* isolates. None of the isolates were resistant to ciprofloxacin, amikacin, or nalidixic acid. None had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 19 and Table C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 72% (113/158) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 39% (61/158) of the isolates, of which most were *S.* Typhimurium (29/61) and *S.* Typhimurium var. 5- (23/61). The most common resistance patterns were ACSSuT (19%, 30/158), STR-SSS-TET (9%, 15/158), and ACKSSuT (8%, 13/158). The pattern involving the greatest number of antimicrobials among isolates was ACKSSuT-A2C-CRO-GEN-SXT (1 *S.* Infantis).

In 2008, resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 1% (2/158) of pig clinical *Salmonella* isolates. The pattern involving the greatest number of antimicrobials among isolates was ACKSSuT-A2C-CRO-GEN-SXT (1 *S.* Infantis).

TABLE 19. Number of antimicrobials in resistance patterns of *Salmonella* isolates from pigs, by serovar; *Surveillance of Animal Clinical Isolates*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Typhimurium	61 (38.6)	13	19	29	0
Typhimurium var. 5-	27 (17.1)	2	2	23	0
Derby	15 (9.5)	1	14	0	0
I 4,[5],12:i:-	8 (5.1)	2	2	4	0
Brandenburg	7 (4.4)	7	0	0	0
Infantis	5 (3.2)	3	1	0	1
Enteritidis	4 (2.5)	4	0	0	0
Less common serovars	31 (19.6)	13	14	4	0
Total	**158 (100)**	**45**	**52**	**60**	**1**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

[1] Distribution of *Salmonella* isolates across provinces is presented in Table C.6, Appendix C.

Farm Surveillance[1]

(n = 1,425)

Recovery: *Escherichia coli* isolates were recovered from 99% (481/486) of fecal samples from pigs. As many as 3 isolates per positive sample were kept for analysis. The expected number of total isolates was 1,449 (483 x 3). Actual isolate recovery was 98% (1,425/1,449). Three samples yielded only 1 isolate, and 11 yielded only 2 isolates. Therefore, 17 expected isolates were not recovered. In addition, 7 isolates could not be cultured after freezing, leaving 1,425 isolates for antimicrobial susceptibility testing.

Antimicrobial Resistance: Results are presented in Figure 29 and Table B.23, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 1% (17/1,425; 15/1,425; and 18/1,425, respectively) of *E. coli* isolates. Less than 1% (3/1,425) of isolates had reduced susceptibility to ciprofloxacin. One percent (5/1,425) of isolates were resistant to nalidixic acid. None of the isolates were resistant to ciprofloxacin or amikacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 87% (1,231/1,425 of *E. coli* isolates. Resistance to 5 or more antimicrobials was detected in 12% (170/1,425). The most common resistance patterns were TET (18%, 256/1,425), AMP-TET (6%, 86/1,425), and SSS-TET (5%, 77/1,425). The pattern involving the greatest number of antimicrobials among isolates was AMC-AMP-CHL-CRO-FOX-GEN-KAN-SSS-SXT-TET-TIO, which was detected in 1 isolate.

Temporal Variations: Results are presented in Figure 30. The percentage of *E. coli* isolates with ceftiofur resistance was significantly higher in 2008 (1%, 15/1,425) than in 2007 (<1%, 7/1,575).[2] There were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 1% (17/1,425, 15/1,425, and 18/1,425, respectively) of farm pig *Escherichia coli* isolates. The percentage of isolates with ceftiofur resistance was significantly higher in 2008 (1%, 15/1,425) than in 2007 (less than 1%, 7/1,575).

[1] The percentages provided in the text and in the figures and tables were adjusted to account for clustering within herds, whereas proportions represent unadjusted values (see Appendix A).

[2] The number of generic *E. coli* isolates recovered through *Farm Surveillance* was much higher than through other surveillance components. The reason for collecting a larger number of isolates in *Farm Surveillance* is to ensure adequate power to investigate the association between antimicrobial resistance and antimicrobial use. A large number of isolates facilitates the identification of statistically significant small changes (such as plus or minus 0.5%), particularly when the prevalence of resistance is around 1%. Although significant, the increase in ceftiofur resistance between 2007 and 2008 (from less than 1% to 1%) may simply reflect natural variation from year to year.

FIGURE 29. Resistance to antimicrobials in *Escherichia coli* isolates from pigs; *Farm Surveillance,* 2008.

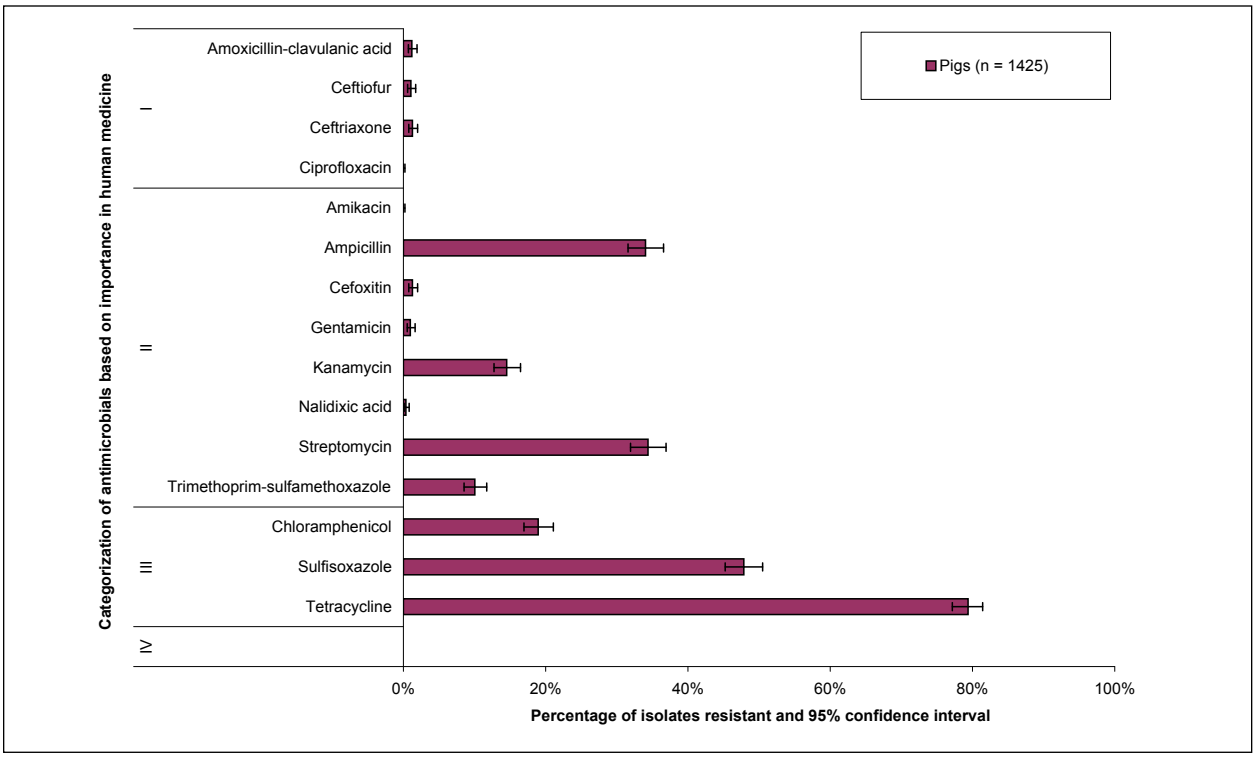
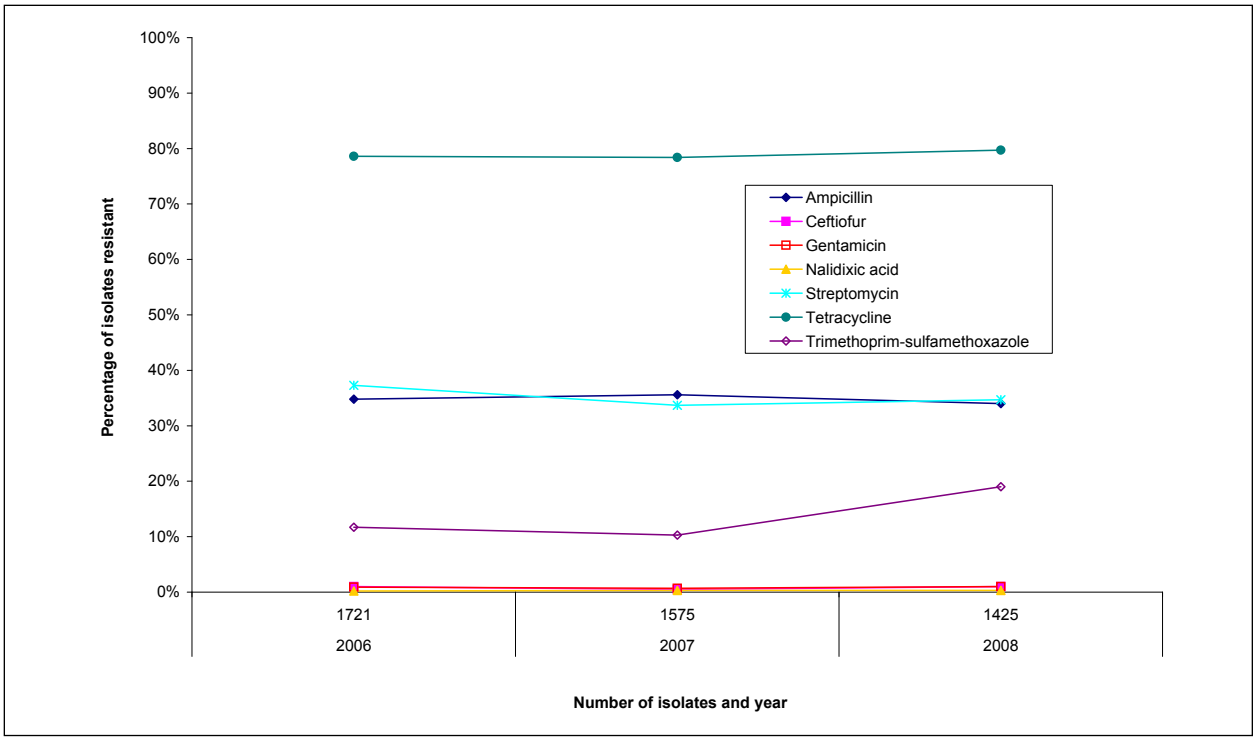


FIGURE 30. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from pigs; *Farm Surveillance*, 2007-2008.



Abattoir Surveillance

(n = 150)

Recovery: *Escherichia coli* isolates were recovered from 100% (150/150) of pig caecal samples (Table C.5, Appendix C)

Antimicrobial Resistance: Results are presented in Figure 31 and Table B.24, Appendix B. One percent (1/150) of *E. coli* isolates were resistant to each of amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone. Reduced susceptibility to ciprofloxacin and resistance to nalidixic acid were each detected in 1% (1/150) of isolates. None of the isolates were resistant to ciprofloxacin, amikacin, or cefoxitin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 89% (133/150) of *E. coli* isolates. Resistance to 5 or more antimicrobials was detected in 13% (20/150). The most common resistance patterns were TET (19%, 29/150), CHL-SSS-TET (6%, 9/150), and STR-TET (6%, 9/150). The isolate with reduced susceptibility to ciprofloxacin was also resistant to ceftriaxone and nalidixic acid. The pattern involving the greatest number of antimicrobials among isolates was AKSSuT-TIO-CRO-GEN-NAL. The isolate associated with this resistance pattern was the isolate with reduced susceptibility to ciprofloxacin.

Temporal Variations: Results are presented in Figure 32. Between 2008 and 2003 and between 2008 and 2007, there were no significant temporal variations in the percentages of *E. coli* isolates with resistance to the selected antimicrobials.

In 2008, resistance to 5 or more antimicrobials was detected in 13% (20/150) of abattoir pig *Escherichia coli* isolates. The pattern involving the greatest number of antimicrobials among isolates was AKSSuT-TIO-CRO-GEN-NAL. The isolate associated with this resistance pattern also had reduced susceptibility to ciprofloxacin.

FIGURE 31. Resistance to antimicrobials in *Escherichia coli* isolates from pigs; *Abattoir Surveillance*, 2008.

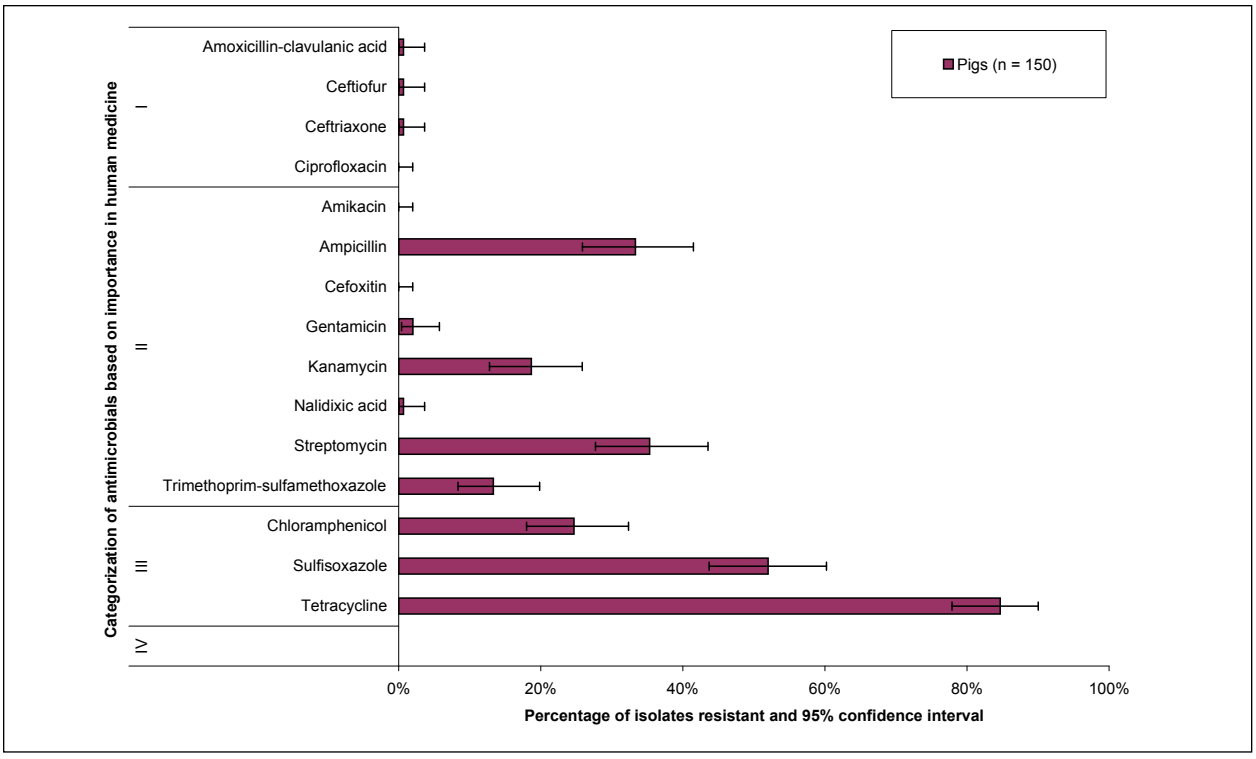
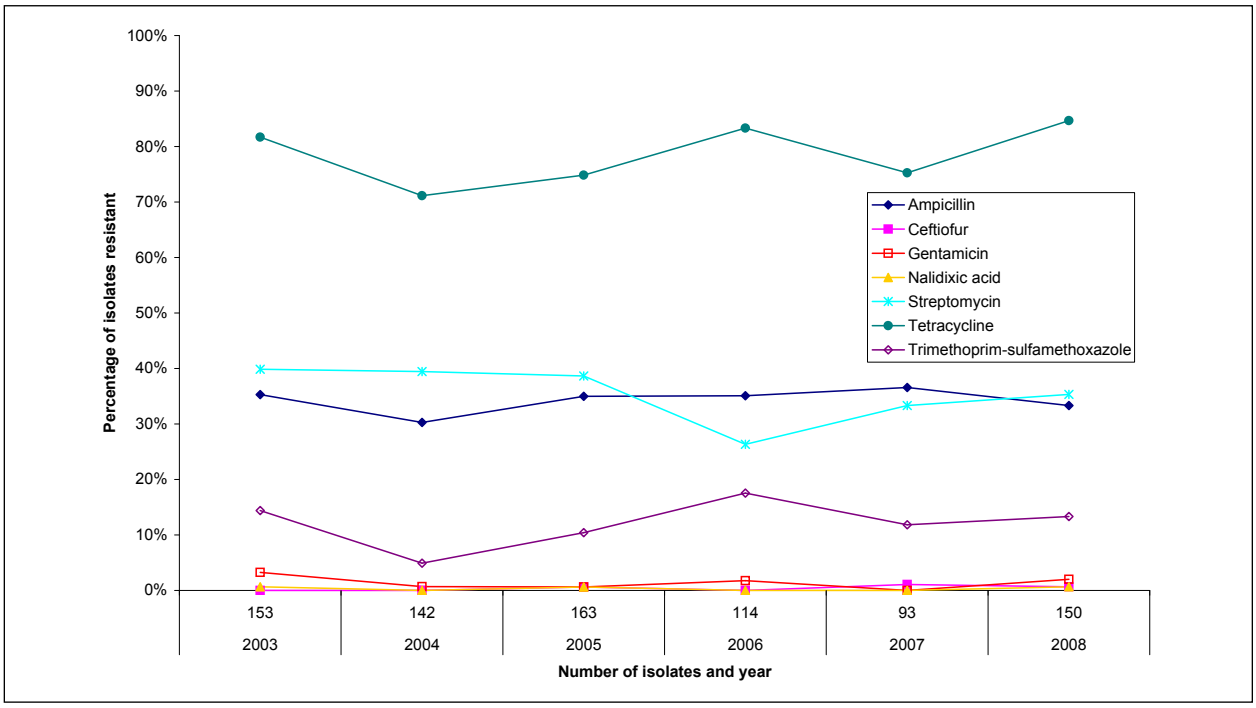


FIGURE 32. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from pigs; *Abattoir Surveillance*, 2003-2008.



Retail Meat Surveillance

(n = 317)
(British Columbia [n = 44], Saskatchewan [n = 41], Ontario [n = 155], Québec [n = 60], Maritimes region [n = 17])

Recovery: *Escherichia coli* isolates were recovered from 32% (317/979) of retail pork samples (Table C.5, Appendix C). Province/region-specific percentages of pork samples from which isolates were recovered were as follows: British Columbia, 30% (44/148); Saskatchewan, 23% (41/176); Ontario, 50% (155/312); Québec, 21% (60/287); and the Maritimes region, 30% (17/56).

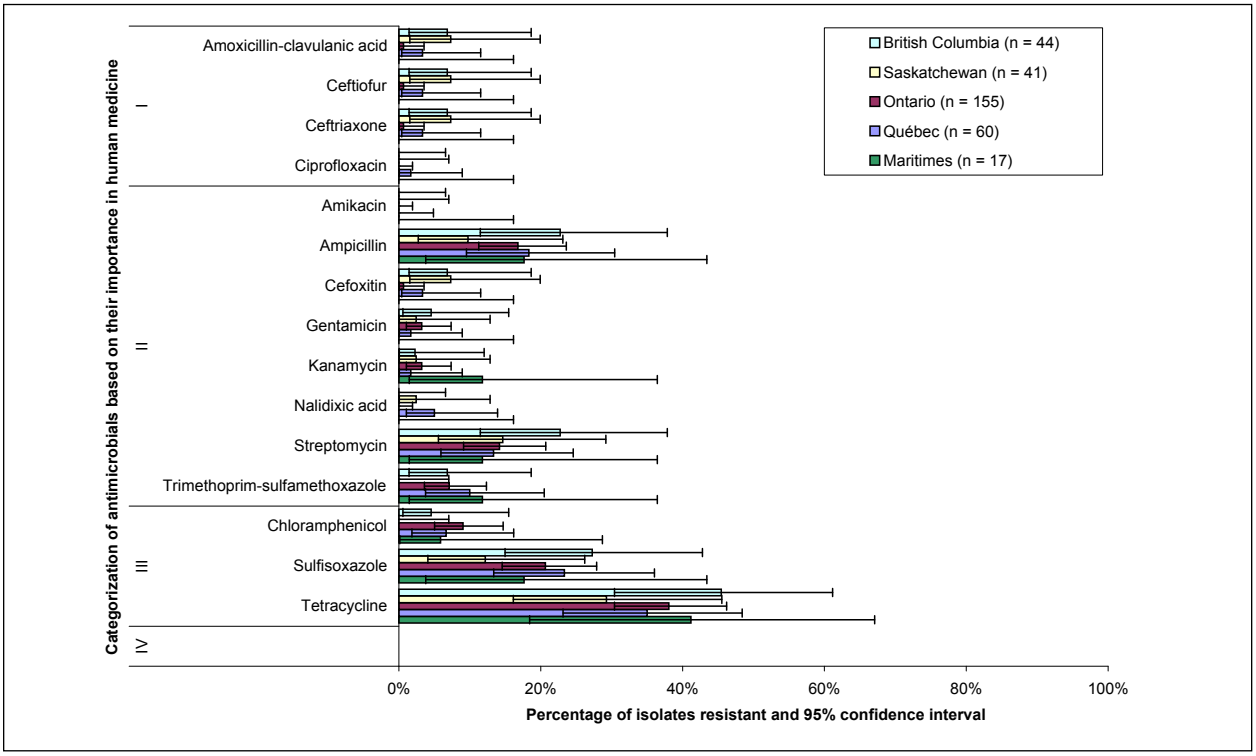
Antimicrobial Resistance: Results are presented in Figure 33 and Table B.25, Appendix B. Resistance to amoxicillin-clavulanic acid was detected in 7% (3/44) of *E. coli* isolates from British Columbia, 7% (3/41) of isolates from Saskatchewan, 1% (1/155) of isolates from Ontario, and 3% (2/60) of isolates from Québec. Resistance to ceftiofur and resistance to ceftriaxone were each detected in 7% (3/44) of isolates from British Columbia, 7% (3/41) of isolates from Saskatchewan, 1% (1/155) of isolates from Ontario, and 3% (2/60) of isolates from Québec. Resistance to ciprofloxacin was detected in 2% (1/60) of isolates from Québec. Reduced susceptibility to ciprofloxacin was detected in 1% (3/317) of all isolates (1 isolate from Saskatchewan and 2 isolates from Québec). Resistance to nalidixic acid was detected in 1% (4/317) of the isolates (1 isolate from Saskatchewan and 3 isolates from Québec). There were no significant differences among the provinces/region in percentages of isolates with resistance to any of the antimicrobials. None of the isolates from any province/region were resistant to amikacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 52% (23/44) of *E. coli* isolates from British Columbia, 39% (16/41) of isolates from Saskatchewan, 41% (63/155) of isolates from Ontario, 42% (25/60) of isolates from Québec, and 7 of 17 isolates from the Maritimes region. Resistance to 5 or more antimicrobials was detected in 9% (4/44) of isolates from British Columbia, 7% (3/41) of isolates from Saskatchewan, 7% (11/155) of isolates from Ontario, 12% (7/60) of isolates from Québec, and 2 of 17 isolates from the Maritimes region. Among the isolates from all 5 provinces/region, the most common resistance patterns were TET (11%, 34/317), AMP-TET (3%, 10/317), and SSS-TET (3%, 8/317). Less than 1% (1/317) of isolates were resistant to ceftriaxone and nalidixic acid, with reduced susceptibility to ciprofloxacin (1 isolate from Québec). The resistance pattern involving the greatest number of antimicrobials was ACSSuT-A2C-CRO-SXT (1 isolate from Ontario).

Temporal Variations: Results are presented in Figure 34. The percentage of *E. coli* isolates from Ontario with resistance to tetracycline was significantly lower in 2008 (38%, 59/155) than in 2003 (55%, 50/91). For the other provinces, there were no significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

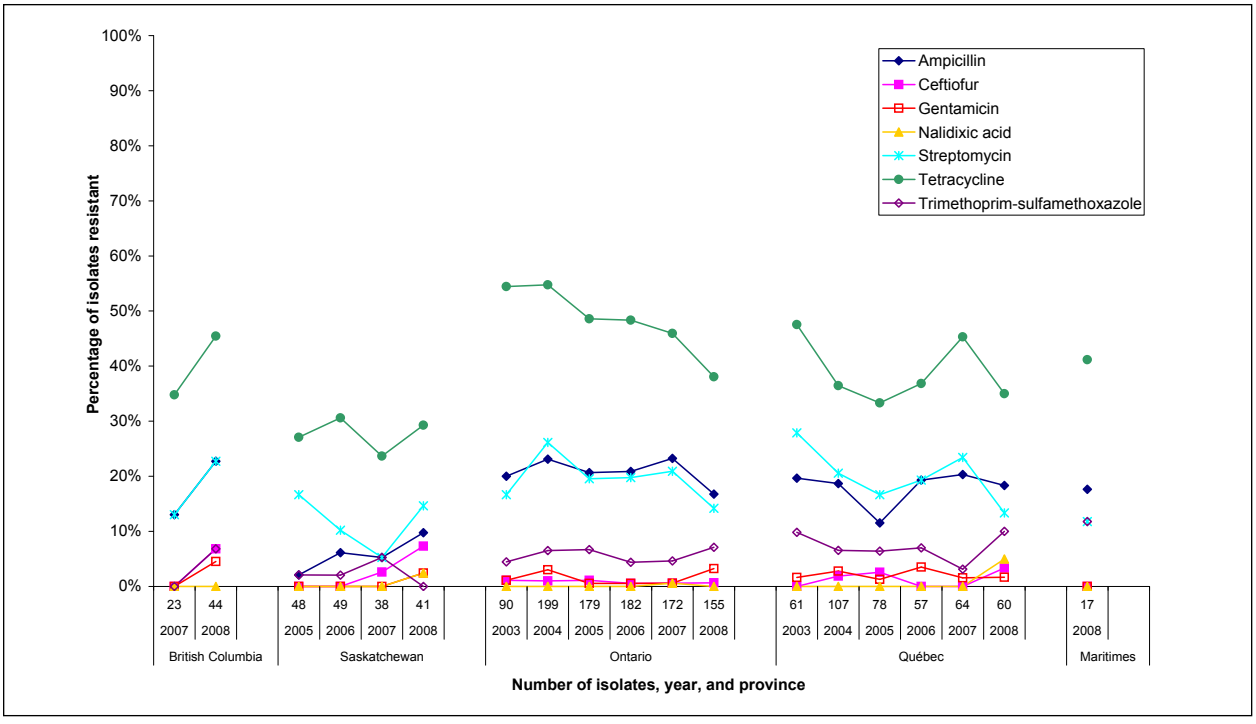
In 2008, resistance to ceftiofur and resistance to ceftriaxone were each detected in 7% (3/44) of retail pork *Escherichia coli* isolates from British Columbia, 7% (3/41) of isolates from Saskatchewan, 1% (1/155) of isolates from Ontario, and 3% (2/60) of isolates from Québec. Resistance to ciprofloxacin was detected in 2% (1/60) of isolates from Québec, and reduced susceptibility to ciprofloxacin was detected in 1% (3/317) of all isolates (1 isolate from Saskatchewan and 2 isolates from Québec). Resistance to ceftriaxone and reduced susceptibility to ciprofloxacin were both detected in less than 1% (1/317) of isolates (1 isolate from Québec), and that isolate was also resistant to nalidixic acid. The percentage of *E. coli* isolates from Ontario with resistance to tetracycline was significantly lower in 2008 (38%, 59/155) than in 2003 (55%, 50/91).

FIGURE 33. Resistance to antimicrobials in *Escherichia coli* isolates from pork, by province/region; *Retail Meat Surveillance*, 2008.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

FIGURE 34. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from pork; *Retail Meat Surveillance*, 2003-2008.



Farm Surveillance[1]

(n = 1,266)

Recovery: *Enterococcus* isolates were recovered from 92% (448/486) of fecal samples from pigs. Up to 3 isolates per positive sample were kept for analysis. The expected number of total isolates was 1,338 (448 x 3). Actual isolate recovery was 95% (1,266/1,338). Sixteen samples yielded only 1 isolate, and 33 yielded only 2 isolates. Therefore, 65 expected isolates were not recovered. In addition, 7 isolates could not be cultured after freezing. Consequently, the number of isolates actually submitted for antimicrobial susceptibility testing was 1,266. Seventy-three percent (918/1,266) of the isolates were *E. faecalis*, 23% (288/1,266) were other *Enterococcus* spp., and 5% (60/1,266) were *E. faecium*.

Antimicrobial Resistance: Results are presented in Figure 35 and Table B.26, Appendix B. Ciprofloxacin resistance was detected in less than 1% (2/918) of *E. faecalis* isolates, in 33% (20/60) of *E. faecium* isolates, and in 1% (3/288) of other *Enterococcus* spp. isolates. Less than 1% (1/918) of *E. faecalis* isolates and none of the *E. faecium* or other *Enterococcus* spp. isolates were non-susceptible to daptomycin. Tigecycline resistance was detected in 2% (15/918) of *E. faecalis* isolates, 2% (1/60) of *E. faecium* isolates, and 2% (6/288) of other *Enterococcus* spp. isolates. None of the isolates were resistant to linezolid or vancomycin. No *E. faecalis* isolates were resistant to penicillin, and no *E. faecium* isolates were resistant to gentamicin.

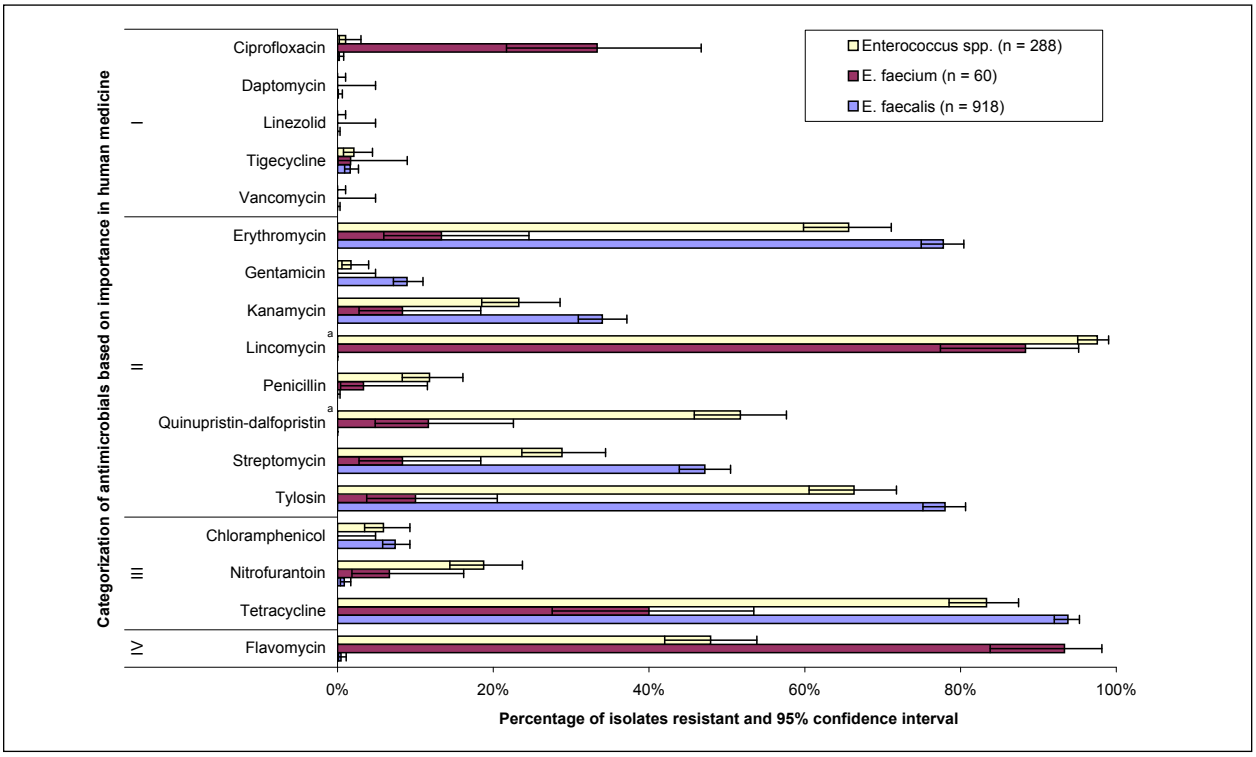
Antimicrobial Resistance Patterns: Results are presented in Table 20. Resistance to 1 or more antimicrobials was detected in 96% (1,213/1,266) of *Enterococcus* isolates. Resistance to 5 or more antimicrobials was detected in 39% (500/1,266). The most common resistance patterns were ERY-TET-TYL (21%, 270/1,266), ERY-KAN-STR-TET-TYL (15%, 188/1,266), and TET (9%, 112/1,266). The patterns involving the greatest number of antimicrobials were ERY-FLA-KAN-LIN-PEN-QDA-STR-TET-TIG-TYL (1 *Enterococcus* spp.) and ERY-FLA-KAN-LIN-NIT-PEN-QDA-STR-TET-TYL (1 *Enterococcus* spp.).

Temporal Variations: Results are presented in Figure 36. The percentage of *Enterococcus* isolates with lincomycin resistance was significantly higher in 2008 (26%, 334/1,266) than in 2006 (20%, 125/641). There were no other significant temporal variations in the percentages of isolates resistant to the selected antimicrobials.

In 2008, ciprofloxacin resistance was detected in 1% or less of farm pig *Enterococcus* (3/288) and other *Enterococcus* spp. (2/918) isolates, and was also identified in 33% (20/60) of *E. faecium* isolates. None of the *Enterococcus* isolates were resistant to linezolid or vancomycin. Less than 1% (1/918) were non-susceptible to daptomycin. The percentage of isolates with lincomycin resistance was significantly higher in 2008 (26%, 334/1,266) than in 2006 (20%, 125/641).

[1] The percentages provided in the text and in the figures and tables were adjusted to account for clustering within herds, whereas proportions represent unadjusted values (see Appendix A).

FIGURE 35. Resistance to antimicrobials in *Enterococcus* isolates from pigs; *Farm Surveillance*, 2008.

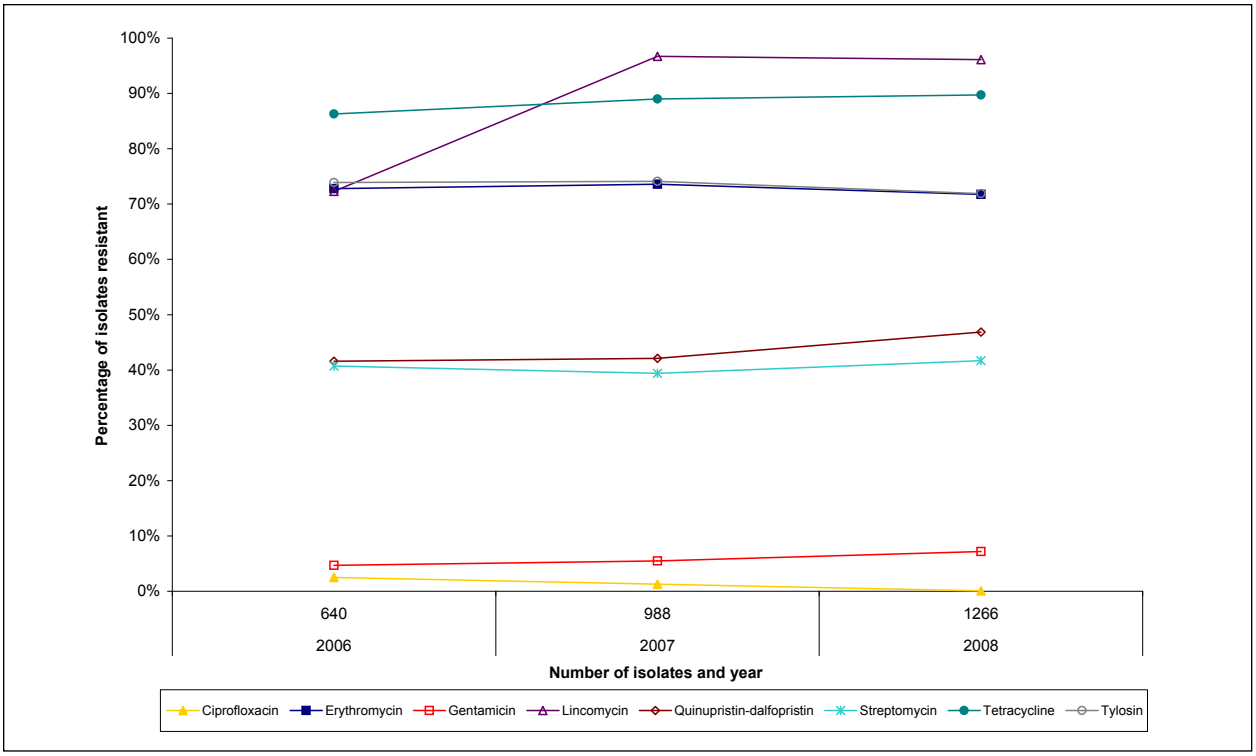


[a] Resistance to quinupristin-dalfopristin and lincomycin is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

TABLE 20. Number of antimicrobials in resistance patterns of *Enterococcus* isolates from pigs, by *Enterococcus* species; *Farm Surveillance*, 2008.

Serovar	n (% total)	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 17
		Number of isolates			
E. faecalis	918 (72.5)	50	560	308	0
E. faecium	60 (4.7)	1	51	7	1
Enterococcus spp.	288 (22.7)	2	102	169	15
Total	**1,266 (100)**	**53**	**713**	**484**	**16**

FIGURE 36. Temporal variation in resistance to selected antimicrobials in *Enterococcus* isolates from pigs; *Farm Surveillance*, 2006-2008.



Salmonella

Surveillance of Animal Clinical Isolates[1]

(n = 32)

Serovars: Results are presented in Table 21 and Table C.2, Appendix C. The most common *Salmonella* serovars among turkey clinical isolates were Typhimurium (22%, 7/32), Agona (13%, 4/32), Hadar (13%, 4/32), and Heidelberg (13%, 4/32). These 3 serovars accounted for 47% (15/32) of the isolates.

Antimicrobial Resistance: Results are presented in Table B.27, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 56% (18/32) of *Salmonella* isolates. None of the isolates were resistant to ciprofloxacin, amikacin, or nalidixic acid. None of the isolates had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 21 and Table C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 91% (29/32) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 59% (19/32). The most common resistance patterns were A2C-AMP-CRO (34%, 11/32) and TET (16%, 5/32). The isolates with the A2C-AMP-CRO resistance pattern were *S.* Typhimurium (19%, 6/32), *S.* Agona (13%, 4/32), and *Salmonella* ssp. I 4,[5],12:-:- (3%, 1/32). The patterns involving the greatest number of antimicrobials were AKSSuT-A2C-CRO-GEN (1 *S.* Senftenberg and 1 *S.* Bredeney) and ACSSuT-A2C-CRO-GEN (1 *S.* Senftenberg).

In 2008, 56% (18/32) of turkey clinical *Salmonella* isolates had resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone. The patterns involving resistance to the most antimicrobials were AKSSuT-A2C-CRO-GEN and ACSSuT-A2C-CRO-GEN, which were detected in 2 isolates (1 *S.* Senftenberg and 1 *S.* Bredeney) and 1 *S.* Senftenberg isolate, respectively.

TABLE 21. Number of antimicrobials in resistance patterns of *Salmonella* isolates from turkeys, by serovar; *Surveillance of Animal Clinical Isolates*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Typhimurium	7 (21.9)	0	0	7	0
Agona	4 (12.5)	0	0	4	0
Hadar	4 (12.5)	0	4	0	0
Heidelberg	4 (12.5)	0	4	0	0
Bredeney	3 (9.4)	0	0	0	3
Senftenberg	3 (9.4)	0	0	1	2
Anatum	1 (3.1)	0	1	0	0
Give	1 (3.1)	1	0	0	0
I 4,[5],12:-:-	1 (3.1)	0	0	1	0
Manhattan	1 (3.1)	1	0	0	0
Montevideo	1 (3.1)	0	0	1	0
Ouakam	1 (3.1)	0	1	0	0
Saintpaul	1 (3.1)	1	0	0	0
Total	**32 (100)**	**3**	**10**	**14**	**5**

[1] Distribution of *Salmonella* isolates across provinces is presented in Table C.6, Appendix C.

Salmonella

Surveillance of Animal Clinical Isolates[1]

(n = 62)

Serovars: Results are presented in Table 22 and Table C.2, Appendix C. The most common *Salmonella* serovars among horse clinical isolates were Heidelberg (42%, 26/62), Newport (13%, 8/62), and Typhimurium (10%, 6/62). These 3 serovars accounted for 65% (40/62) of the isolates.

Antimicrobial Resistance: Results are presented in Table B.28, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 11% (7/62) of *Salmonella* isolates. Reduced susceptibility to ciprofloxacin was detected in 40% (25/62). None of the isolates were resistant to ciprofloxacin, amikacin, or nalidixic acid.

Antimicrobial Resistance Patterns: Results are presented in Table 22 and Table C.4, Appendix C. Resistance to 1 or more antimicrobials was detected in 55% (34/62) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 52% (32/62). The most common resistance patterns were AMP-GEN-KAN-SSS-SXT (21%, 13/62), AMP-CHL-GEN-KAN-SSS-SXT (15%, 9/62), and A2C-AMP-CRO (10%, 6/62). All isolates with the AMP-GEN-KAN-SSS-SXT and AMP-CHL-GEN-KAN-SSS-SXT resistance patterns were *S.* Heidelberg. Two percent (1/62) of isolates were resistant to ceftriaxone and had reduced susceptibility to ciprofloxacin. Forty percent (25/62) of isolates had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. The pattern involving the greatest number of antimicrobials was A2C-AMP-CRO-GEN-KAN-SSS-SXT (1 *S.* Heidelberg).

In 2008, reduced susceptibility to ciprofloxacin was detected in 40% (25/62) of horse clinical *Salmonella* isolates. Two percent (1/62) of isolates were resistant to ceftriaxone and had reduced susceptibility to ciprofloxacin. Resistance to 5 or more antimicrobials was detected in 52% (32/62) of the isolates. The pattern involving resistance to the most antimicrobials was A2C-AMP-CRO-GEN-KAN-SSS-SXT (1 *S.* Heidelberg).

Table 22. Number of antimicrobials in resistance patterns of *Salmonella* isolates from horses, by serovar; *Surveillance of Animal Clinical Isolates*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Heidelberg	26 (41.9)	0	0	25	1
Newport	8 (12.9)	8	0	0	0
Typhimurium	6 (9.7)	6	0	0	0
Litchfield	5 (8.1)	0	0	5	0
Thompson	5 (8.1)	5	0	0	0
Oranienburg	4 (6.5)	4	0	0	0
Agona	2 (3.2)	0	2	0	0
Less common serovars	6 (9.7)	5	0	1	0
Total	**62 (100)**	**28**	**2**	**31**	**1**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

[1] Distribution of *Salmonella* isolates across provinces is presented in Table C.6, Appendix C.

Salmonella

(n = 57)

Note: These data include those obtained from Government Monitoring Programs in 2008. The *Salmonella* isolates originated from samples of feed destined for consumption by various animal species: 28% (16/57) for dogs, 9% (4/57) for swine, 4% (2/57) for poultry, and 2% (1/57) for each of beef cattle, dairy cattle, horses, and minks. Information about the intended use of the feed was missing for 54% (31/57) of the isolates.

Serovars: Results are presented in Table 23. The most common *Salmonella* serovars were London (16%, 9/57), Montevideo (9%, 5/57), Cubana (7%, 4/57), Mbandaka (7%, 4/57), and Rissen (7%, 4/57). Typhimurium and Typhimurium var. 5- each accounted for 2% (1/57) of isolates. No isolates of Enteritidis, Heidelberg, or Newport were recovered.

Antimicrobial Resistance: Results are presented in Table B.29, Appendix B. Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone were each detected in 2% (1/57) of *S.* Typhimurium isolates. No resistance or reduced susceptibility to ciprofloxacin was detected in any *Salmonella* isolate. None of the isolates were resistant to amikacin, gentamicin, kanamycin, nalidixic acid, or trimethoprim-sulfamethoxazole.

Antimicrobial Resistance Patterns: Results are presented in Table 23. Resistance to 1 or more antimicrobials was detected in 11% (6/57) of *Salmonella* isolates. For the first time since 2002, resistance to 5 or more antimicrobials was detected in feed isolates (5%, 3/57). The most common resistance patterns were STR, STR-TET, STR-SSS, ACSSuT, A2C-AMP-CRO, and CHL-STR-SSS-TET-SXT (2%, 1/57 each). The patterns involving the greatest number of antimicrobials were ACSSuT (1 *S.* Typhimurium var. 5- isolate recovered from feed intended for dogs), A2C-AMP-CRO (1 *S.* Typhimurium isolate recovered from an unknown feed source), and CHL-STR-SSS-TET-SXT (1 *S.* Worthington isolate recovered from feed intended for minks).

In 2008, resistance to 1 or more antimicrobials was detected in 11% (6/57) of feed isolates of *Salmonella*. For the first time since 2002, resistance to 5 or more antimicrobials was detected in feed isolates (5%, 3/57). One of these, an isolate of *S.* Typhimurium var. 5- had the ACSSuT resistance pattern and was recovered from feed intended for dogs.

TABLE 23. Number of antimicrobials in resistance patterns of *Salmonella* isolates from animal feed, by serovar; *Feed and Feed Ingredients*, 2008.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
London	9 (15.8)	9	0	0	0
Montevideo	5 (8.8)	5	0	0	0
Cubana	4 (7.0)	4	0	0	0
Mbandaka	4 (7.0)	3	1	0	0
Rissen	4 (7.0)	3	1	0	0
Anatum	3 (5.3)	3	0	0	0
Infantis	3 (5.3)	3	0	0	0
Schwarzengrund	3 (5.3)	3	0	0	0
Cerro	2 (3.5)	2	0	0	0
Johannesburg	2 (3.5)	2	0	0	0
Senftenberg	2 (3.5)	2	0	0	0
Tennessee	2 (3.5)	2	0	0	0
Less common serovars	14 (24.6)	10	1	3	0
Total	**57 (100)**	**51**	**3**	**3**	**0**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

Humans

Canadian CompuScript Data

For the CIPARS analysis of antimicrobial use in humans, data were obtained from the Canadian CompuScript (CCS) dataset provided by Intercontinental Medical Statistics (IMS) Health for 2000 through 2008. This dataset provides information on prescriptions dispensed by Canadian retail pharmacies. Additional information on IMS Health data collection and CIPARS analytic methods is provided in Appendix A. Information on the total volume of active ingredients of oral antimicrobials and on population demographics is available in Tables C.7 and C.8 (Appendix C), respectively.

Canada Overall

In 2008, there was a decrease in the antimicrobial prescription dispensing rate (Table 24 and Figure 37) to the lowest level observed (671.16 prescriptions/1,000 inhabitants) during the 9-year surveillance period. The total expenditure ($20,555/1,000 inhabitants) was the second lowest observed during the same period (Figure 37). Compared with expenditures in 2007, expenditures in 2008 related to combinations of penicillins (including ß-lactamase inhibitors), third-generation cephalosporins, fluoroquinolones, ß-lactamase sensitive penicillins, ß-lactamase resistant penicillins, and combinations of sulfonamides and trimethoprim (including derivatives) increased but remained lower than in 2000 (Table 25). On the other hand, expenditures related to glycopeptides, imidazole, linezolid, penicillins with extended spectrum, first-generation cephalosporins, lincosamides, and nitrofuran derivatives were higher in 2008 than in 2007 and 2000 (Table 25).

The 4 most commonly dispensed systemic antimicrobial classes in 2008 (in DDDs/1,000 inhabitant-days) were penicillins with extended spectrum (4.43), macrolides (3.73), tetracyclines (2.38), and fluoroquinolones (2.06; Table 26 and Figure 38). Although fluoroquinolones represented a lower number of DDD/1,000 inhabitant-days than tetracyclines, they were almost 3 times more frequently prescribed and cost 3 times more per 1,000 inhabitants (Tables 24, 25, and 26). Category I antimicrobials continued to represent a high proportion (17%, 3.08/17.91) of the total DDDs dispensed (Table 27).

The consumption[1] of drugs in most classes decreased or remained stable between 2000 and 2008 (Table 26). However, increases in DDDs/1,000 inhabitant-days were observed for combinations of penicillins, including ß-lactamase inhibitors (amoxicillin-clavulanic acid, from 0.51 to 0.71), first-generation cephalosporins (driven primarily by cefadroxil, from 0.75 to 0.98), lincosamides (driven primarily by clindamycin, from 0.24 to 0.38), and nitrofuran derivatives (nitrofurantoin, from 0.42 to 0.61).

Consumption was slightly lower in 2008 than in 2007 for fluoroquinolones (2.06 and 2.09 DDDs per 1,000 inhabitant-days, respectively) and for macrolides (3.73 and 3.75 DDDs, respectively; Table 26). Among the fluoroquinolones, this decrease was explained mainly by small decreases in the consumption of norfloxacin and moxifloxacin (0.17 to 0.15 DDDs and 0.43 to 0.42 DDDs, respectively; Figure 39). Interestingly, the consumption of moxifloxacin markedly increased, from 0.01 DDDs in 2000 to 0.43 DDDs in 2007 (Figure 39).

Among the macrolides, most of the decrease observed between 2007 and 2008 was attributable to a decrease in consumption of erythromycin (0.27 DDDs per 1,000 inhabitant-days in 2007 to 0.25 DDDs in 2008; Figure 40). Overall, the consumption of erythromycin continuously decreased from 0.88 DDDs in 2000 to 0.25 DDDs in 2008. Consumption of clarithromycin continued to increase from 2.18 DDDs in 2004 to 2.68 DDDs in 2007 and 2.70 DDDs in 2008 (Figure 40).

[1] Defined daily dosages were computed from data on dispensed prescriptions for orally administered antimicrobials. However, an unknown proportion of the drugs sold by retail pharmacies is not consumed. To improve text clarity, the word "consumption" is used, although the total DDD estimates presented slightly overestimate true consumption.

Provincial Variations

In 2008, differences in the total consumption of oral antimicrobials (in DDDs/1,000 inhabitant-days) and total cost in dollars (per 1,000 inhabitant-days) were observed across Canada (Table 27 and Figure 41). Much of the inter-provincial variation in DDDs could be explained by differences in consumption of penicillins with extended spectrum, fluoroquinolones, tetracyclines, macrolides, first-generation cephalosporins, and combinations of sulfonamides and trimethoprim (including derivatives; Table 27 and Figure 41). Consumption and total cost per 1,000 inhabitant-days were still the highest in Newfoundland and Labrador (30.20 DDDs and $84.75, respectively), whereas Québec had the lowest overall antimicrobial consumption and total cost (13.54 DDDs and $48.85, respectively).

Compared with consumption in Québec, consumption in Newfoundland and Labrador was driven primarily by higher consumption of antimicrobials belonging to the classes penicillins with extended spectrum, fluoroquinolones, and macrolides (Table 27). The higher consumption of fluoroquinolones was attributable to ciprofloxacin consumption (3.53 DDDs in Newfoundland and Labrador vs. 1.13 DDDs in Québec). Ciprofloxacin consumption increased over the years (assuming the trend in the combined data from Prince Edward Island and Newfoundland and Labrador before 2005 was mostly influenced by consumption in Newfoundland and Labrador) but appeared to have reached a plateau in 2007 and 2008 (Figure 42). The high macrolide consumption was attributable to clarithromycin (4.55 DDDs in Newfoundland and Labrador vs. 2.52 DDDs in Québec).

Saskatchewan had the second highest total consumption of antimicrobials in 2008, driven by higher consumption of antimicrobials belonging to the classes penicillins with extended spectrum, tetracyclines, macrolides, and first-generation cephalosporins (Table 27). The higher consumption of tetracyclines was attributable to the consumption of doxycycline, which has always been higher and has increased in Saskatchewan, compared with consumption in other provinces (Figure 43). Total doxycycline consumption in Saskatchewan in 2008 was 3.29 DDDs, compared with 0.46 DDDs in Québec during the same year. In Saskatchewan, the high consumption of first-generation cephalosporins was influenced by levels of consumption of cephalexin (2.01 DDDs in Saskatchewan vs. 0.26 DDDs in Québec). Despite higher overall antimicrobial consumption in Saskatchewan than in Québec in 2008, consumption of antimicrobial classes such as fluoroquinolones and macrolides was lower in Saskatchewan than in Québec (fluoroquinolones, 1.41 DDDs vs. 1.96 DDDs, respectively; and macrolides, 2.94 DDDs vs. 3.19 DDDs, respectively).

As mentioned previously, consumption of moxifloxacin increased from 2000 to 2007 then slightly decreased from 2007 to 2008. The increase between 2000 and 2007 was observed in all provinces (Figure 44). Québec, New Brunswick, and Prince Edward Island had the highest increase in the level of consumption during this period. From 2007 to 2008, a decrease in moxifloxacin consumption was observed in Ontario and Québec, while consumption in all other provinces either increased or remained stable (Figure 44).

Also as mentioned, clindamycin consumption continued to increase since 2000. Until 2007, the province of Alberta had the highest levels of consumption (Figure 45). Toward the latter half of 2007 and throughout 2008, an increase in consumption was observed in Saskatchewan, making consumption of clindamycin in that province higher than consumption in Alberta during that same period (0.48 DDDs vs. 0.47 DDDs, respectively, in the latter half of 2007; and 0.53 DDDs vs. 0.49 DDDs, respectively, in 2008; Figure 45).

International Comparisons

The estimate of the total amount of oral antimicrobials dispensed in 2007 by Canadian retail pharmacies was compared with the total amount of outpatient antimicrobial use in 19 European countries[1] in the same year (Figure 46). This comparison showed that the level of consumption in Canada was similar to the level of consumption in Finland and Denmark. Canada's oral antimicrobial consumption represented almost twice the level of antimicrobial consumption reported by the Russian Federation (the country with the lowest level of consumption) and half the level estimated in Cyprus (the country with the highest level of consumption). Whereas Canada ranked 9th out of the 20 countries classified by increasing level of total antimicrobial consumption, it ranked 18th for its level of consumption of macrolides and lincosamides, and 13th for its level of consumption of quinolones (largely consisting of fluoroquinolones). Canada was among the top 5 countries with the lowest level of penicillins consumption.

In 2008, there were decreases in the oral antimicrobial prescription dispensing rate and total oral antimicrobial expenditure to the lowest level observed during the 9-year surveillance period. Category I antimicrobials continued to represent a high proportion (17%, 3.08/17.91) of the total DDDs dispensed during 2008.

In that same year, oral antimicrobial consumption was still highest in Newfoundland and Labrador (30.20 DDDs/1,000 inhabitant-days) and lowest in Québec (13.54 DDDs/1,000 inhabitant-days). Much of the inter-provincial variation in DDDs could be explained by differences in consumption of fluoroquinolones, first-generation cephalosporins, penicillins with extended spectrum, combinations of sulfonamides and trimethoprim (including derivatives), tetracyclines, and macrolides.

When the total amount of oral antimicrobials dispensed in 2007 by Canadian retail pharmacies was compared with the total outpatient antimicrobial use in 19 European countries in the same year, Canadian consumption was similar to the level of consumption in Finland and Denmark. Canada ranked 9th out of the 20 countries classified by increasing level of total antimicrobial consumption.

[1] European Surveillance of Antimicrobial Consumption. ESAC Yearbook 2007. Available at: www.esac.ua.ac.be/main.aspx?c=*ESAC2&n=50036. Accessed March 2010.

Note: Data were available for Malta but were not included in the comparisons because the numbers were too low (i.e. 1.7 DDDs/1,000 inhabitants).

TABLE 24. Total number of prescriptions of oral antimicrobials dispensed by retail pharmacies per 1,000 Canadian inhabitants, 2000-2008.

	ATC Class		Number of prescriptions/1,000 inhabitants								
			2000	2001	2002	2003	2004	2005	2006	2007	2008
	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	18.66	18.41	17.54	17.69	16.98	18.66	19.38	19.70	20.58
	J01DD	Third-generation cephalosporins	5.66	5.28	4.83	4.23	3.68	3.74	3.78	3.99	4.24
I	J01MA	Fluoroquinolones	76.23	81.03	85.73	91.74	94.22	95.30	98.77	97.50	97.47
	J01XA	Glycopeptides	0.14	0.14	0.16	0.19	0.34	0.39	0.38	0.41	0.43
	J01XD	Imidazole	NA	16.65	16.71	17.09	17.25	17.41	18.51	17.70	18.09
	J01XX	Linezolid	NA	< 0.01	0.01	0.02	0.04	0.04	0.05	0.05	0.06
	J01CA	Penicillins with extended spectrum	193.18	183.54	171.05	169.81	156.08	168.34	168.98	158.55	155.97
	J01CE	ß-lactamase sensitive penicillins	45.42	42.10	39.85	39.62	36.59	36.89	37.26	34.89	32.94
	J01CF	ß-lactamase resistant penicillins	19.78	18.38	16.78	15.61	14.17	12.49	11.89	10.35	9.32
	J01DB	First-generation cephalosporins	41.03	41.70	43.07	45.23	45.65	48.36	51.51	49.96	50.22
	J01DC	Second-generation cephalosporins	55.09	48.95	43.06	41.41	39.37	39.65	37.43	32.68	30.85
	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	56.52	50.62	44.56	41.05	37.12	35.15	35.47	33.63	33.59
II	J01FA	Macrolides	146.55	149.72	145.48	149.00	138.51	149.25	147.00	134.76	132.91
	J01FF	Lincosamides	15.92	16.74	17.63	18.48	18.85	19.73	21.89	21.97	22.17
	J01GB	Aminoglycosides	0.06	< 0.01	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01	< 0.01
	J01MB	Other quinolones, excluding fluoroquinolones	0.08	0.06	0.05	0.04	0.05	< 0.01	< 0.01	< 0.01	NA
	J01RA	Sulfonamide combinations, excluding trimethoprim	3.50	2.43	1.58	1.05	0.67	0.60	0.52	0.36	0.12
	J01XC	Steroid antimicrobials	0.06	0.06	0.05	0.05	0.05	0.06	0.07	0.05	0.04
	J01AA	Tetracyclines	43.47	41.16	39.31	38.41	36.71	36.33	37.01	35.29	35.26
	J01BA	Amphenicols	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01	NA	NA	NA
	J01EA	Trimethoprim and derivatives	2.22	2.12	2.13	2.16	2.02	1.85	1.96	1.93	1.87
III	J01EB	Short-acting sulfonamides	0.07	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
	J01EC	Intermediate-acting sulfonamides	0.02	< 0.01	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
	J01XE	Nitrofuran derivatives	14.61	15.76	16.41	17.48	19.13	20.35	22.70	23.16	24.86
	J01XX	Fosfomycin	0.44	0.47	0.29	0.21	0.14	0.11	0.09	0.05	0.01
NC	J01XX	Methenamine	0.27	0.28	0.29	0.28	0.25	0.23	0.23	0.23	0.16
	J01	**Total**	**738.98**	**735.62**	**706.57**	**710.89**	**677.86**	**704.95**	**714.86**	**677.21**	**671.16**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

ATC = Anatomical Therapeutic Chemical. NA = Not available. NC = Not classified. DDD = Defined daily dose.

FIGURE 37. Total number of prescriptions and total cost per 1,000 inhabitants for oral antimicrobials dispensed by retail pharmacies in Canada, 2000-2008.

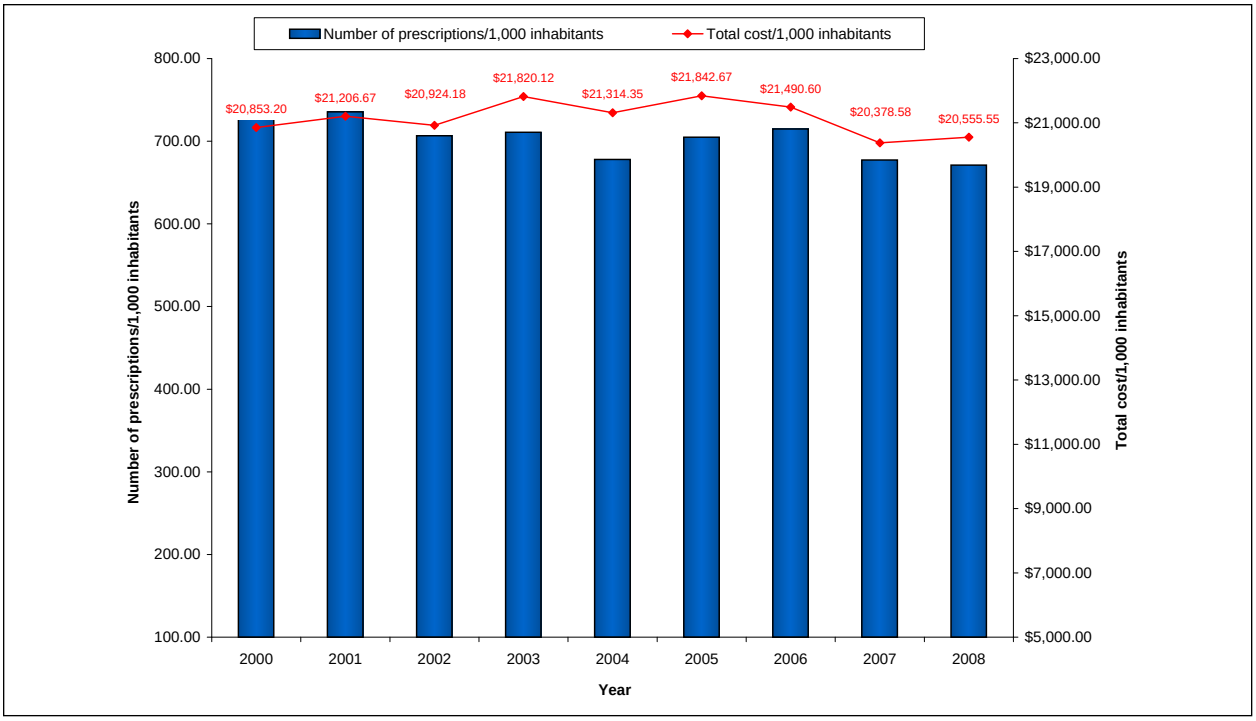


TABLE 25. Total cost per 1,000 inhabitants for oral antimicrobials dispensed by retail pharmacies in Canada, 2000-2008.

	ATC Class		Total cost per 1,000 inhabitants ($)								
			2000	2001	2002	2003	2004	2005	2006	2007	2008
	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	758.68	741.82	644.84	632.84	584.65	631.09	663.15	670.56	691.42
	J01DD	Third-generation cephalosporins	212.26	196.78	179.57	155.33	133.22	137.49	136.27	147.62	159.08
I	J01MA	Fluoroquinolones	4,285.71	4,555.96	4,758.29	5,078.69	4,859.20	4,280.24	4,176.95	4,186.70	4,193.17
	J01XA	Glycopeptides	51.03	54.88	62.08	76.38	131.23	148.95	145.53	159.22	164.39
	J01XD	Imidazole	NA	198.89	224.55	243.26	261.21	268.74	295.81	282.05	291.46
	J01XX	Linezolid	NA	6.36	19.53	43.61	71.59	95.82	91.62	98.97	100.56
	J01CA	Penicillins with extended spectrum	2,662.57	2,559.11	2,416.25	2,456.31	2,295.16	2,452.44	2,471.71	2,388.21	2,892.46
	J01CE	ß-lactamase sensitive penicillins	497.32	467.30	452.74	463.27	435.95	432.11	438.39	420.95	449.32
	J01CF	ß-lactamase resistant penicillins	287.70	272.68	251.58	242.19	226.14	197.11	189.04	168.97	199.70
	J01DB	First-generation cephalosporins	736.71	756.44	798.94	863.21	890.36	933.03	1,000.28	980.14	1,217.12
	J01DC	Second-generation cephalosporins	2,335.89	2,134.36	1,820.11	1,807.37	1,797.76	1,851.94	1,815.35	1,540.74	1,290.18
	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	632.11	571.05	511.01	481.11	438.79	407.76	412.08	398.12	398.97
II	J01FA	Macrolides	5,800.28	6,177.44	6,219.24	6,639.65	6,521.81	7,292.34	6,782.48	6,102.54	5,720.74
	J01FF	Lincosamides	666.80	605.60	635.04	654.75	675.26	698.80	773.51	781.40	783.02
	J01GB	Aminoglycosides	0.93	0.02	< 0.01	< 0.01	< 0.01	NA	< 0.01	0.01	< 0.01
	J01MB	Other quinolones, excluding fluoroquinolones	3.62	3.01	2.53	2.27	2.16	0.07	0.02	< 0.01	NA
	J01RA	Sulfonamide combinations, excluding trimethoprim	95.14	66.22	43.47	29.38	19.60	18.21	15.81	11.31	3.82
	J01XC	Steroid antimicrobials	6.14	6.74	6.04	6.30	6.24	6.94	7.21	5.58	4.64
	J01AA	Tetracyclines	1,456.11	1,451.83	1,485.89	1,524.95	1,512.46	1,516.34	1,548.07	1,492.19	1,415.61
	J01BA	Amphenicols	0.02	0.05	0.01	NA	< 0.01	< 0.01	NA	NA	NA
	J01EA	Trimethoprim and derivatives	47.67	43.68	41.75	39.62	35.03	31.60	32.45	31.43	29.38
III	J01EB	Short-acting sulfonamides	2.79	0.35	0.03	0.02	0.02	< 0.01	0.01	< 0.01	< 0.01
	J01EC	Intermediate-acting sulfonamides	0.45	0.40	0.32	0.48	0.22	0.17	0.16	0.18	0.14
	J01XE	Nitrofuran derivatives	290.94	312.33	332.83	364.93	404.48	431.71	485.87	504.05	546.27
	J01XX	Fosfomycin	14.71	16.06	10.39	7.60	5.52	4.43	3.59	2.11	0.39
NC	J01XX	Methenamine	7.64	7.27	7.14	6.59	6.31	5.34	5.23	5.51	3.67
	J01	**Total**	**20,853.20**	**21,206.67**	**20,924.18**	**21,820.12**	**21,314.35**	**21,842.67**	**21,490.60**	**20,378.58**	**20,555.55**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

ATC = Anatomical Therapeutic Chemical. NA = Not available. NC = Not classified.

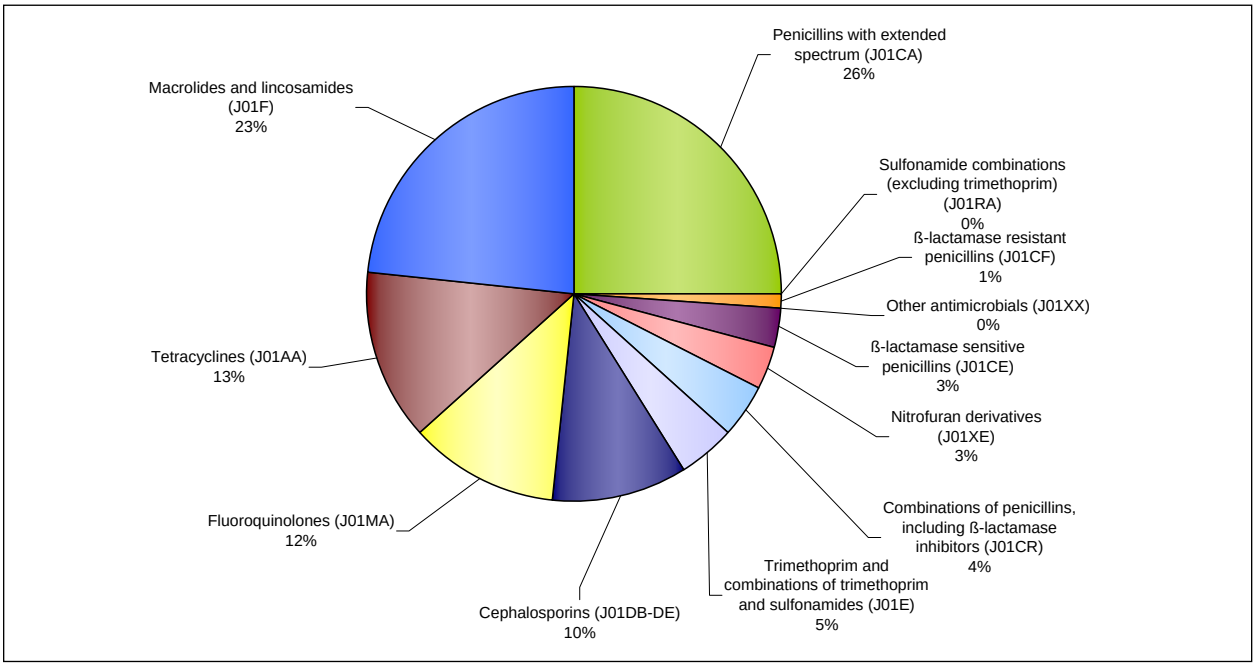
TABLE 26. Defined daily doses (DDDs) per 1,000 inhabitant-days for oral antimicrobials dispensed by retail pharmacies in Canada, 2000-2008.

	ATC Class		DDDs/1,000 inhabitant-days								
			2000	2001	2002	2003	2004	2005	2006	2007	2008
I	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	0.51	0.52	0.50	0.52	0.52	0.59	0.64	0.67	0.71
	J01DD	Third-generation cephalosporins	0.10	0.09	0.08	0.07	0.06	0.06	0.06	0.06	0.07
	J01MA	Fluoroquinolones	1.83	1.93	1.99	2.08	2.09	2.08	2.14	2.09	2.06
	J01XA	Glycopeptides	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
	J01XD	Imidazole	NA	0.21	0.22	0.22	0.22	0.23	0.24	0.23	0.24
	J01XX	Linezolid	NA	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
II	J01CA	Penicillins with extended spectrum	5.07	4.90	4.63	4.57	4.38	4.52	4.61	4.42	4.43
	J01CE	ß-lactamase sensitive penicillins	0.67	0.63	0.60	0.60	0.55	0.56	0.57	0.54	0.51
	J01CF	ß-lactamase resistant penicillins	0.37	0.35	0.32	0.31	0.28	0.25	0.24	0.21	0.19
	J01DB	First-generation cephalosporins	0.75	0.77	0.80	0.85	0.87	0.92	1.00	0.97	0.98
	J01DC	Second-generation cephalosporins	1.39	1.22	1.05	1.00	0.94	0.96	0.91	0.83	0.80
	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	1.39	1.25	1.12	1.04	0.92	0.84	0.84	0.78	0.77
	J01FA	Macrolides	3.64	3.62	3.42	3.57	3.43	3.77	3.86	3.75	3.73
	J01FF	Lincosamides	0.24	0.27	0.28	0.31	0.32	0.32	0.36	0.37	0.38
	J01GB	Aminoglycosides	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01	< 0.01
	J01MB	Other quinolones, excluding fluoroquinolones	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NA
	J01RA	Sulfonamide combinations, excluding trimethoprim	0.03	0.02	0.01	0.01	0.01	0.01	< 0.01	< 0.01	< 0.01
	J01XC	Steroid antimicrobials	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
III	J01AA	Tetracyclines	2.72	2.62	2.54	2.50	2.40	2.42	2.47	2.37	2.38
	J01BA	Amphenicols	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01	NA	NA	NA
	J01EA	Trimethoprim and derivatives	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
	J01EB	Short-acting sulfonamides	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05
	J01EC	Intermediate-acting sulfonamides	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
	J01XE	Nitrofuran derivatives	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
	J01XX	Fosfomycin	0.42	0.44	0.45	0.47	0.49	0.52	0.57	0.58	0.61
NC	J01XX	Methenamine	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	< 0.01
	J01	**Total**	**19.23**	**18.93**	**18.11**	**18.21**	**17.58**	**18.13**	**18.58**	**17.95**	**17.91**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

ATC = Anatomical Therapeutic Chemical. NA = Not available. NC = Not classified.

FIGURE 38. Percentages of total number of defined daily doses (DDDs) per 1,000 inhabitant-days for oral antimicrobials dispensed by retail pharmacies in Canada, 2008.



Alphanumeric codes in parentheses represent Anatomical Therapeutic Chemical classes of antimicrobials.

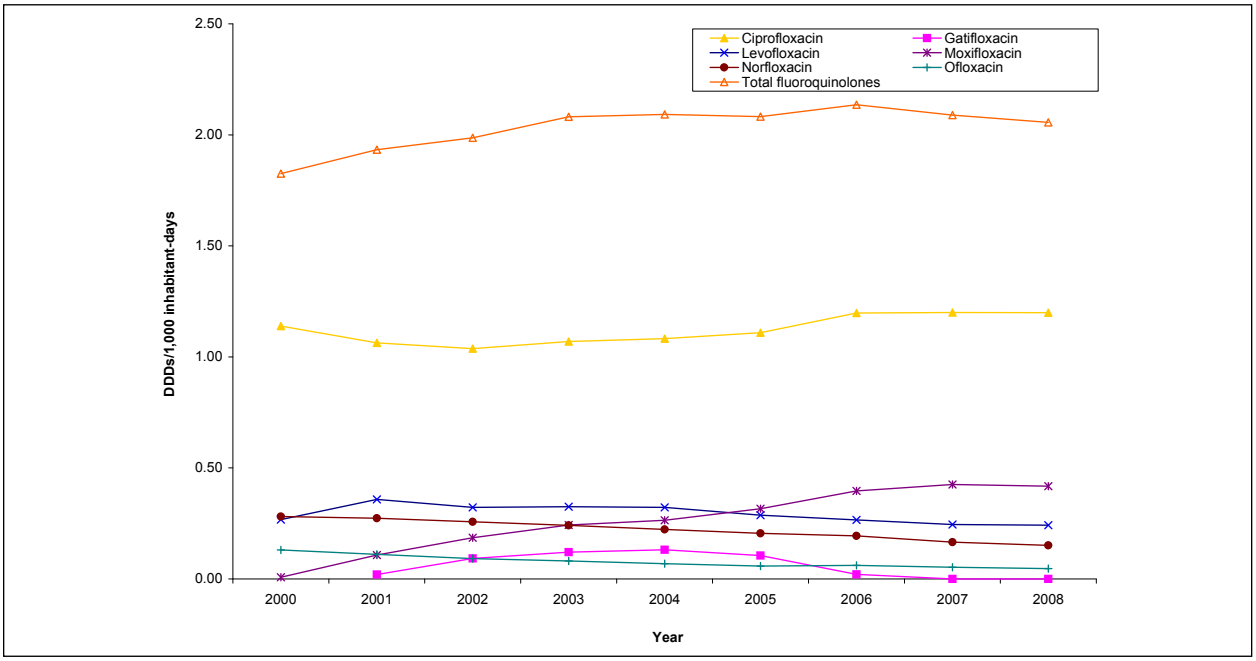
TABLE 27. Total consumption (DDDs/1,000 inhabitant-days) of oral antimicrobials dispensed by retail pharmacies in Canadian provinces, 2008.

	ATC Class		DDDs/1,000 inhabitant-days									
			BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL
I	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	0.69	0.79	0.60	0.65	0.56	0.88	0.74	0.87	1.46	1.60
	J01DD	Third-generation cephalosporins	0.07	0.06	0.02	0.05	0.08	0.04	0.07	0.09	0.24	0.21
	J01MA	Fluoroquinolones	1.71	2.09	1.41	1.91	2.22	1.96	2.02	1.93	2.53	4.55
	J01XA	Glycopeptides	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
	J01XD	Imidazole	0.24	0.26	0.28	0.28	0.25	0.19	0.23	0.27	0.23	0.31
	J01XX	Linezolid	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NA	< 0.01
II	J01CA	Penicillins with extended spectrum	4.17	4.82	6.61	5.58	4.99	2.69	5.05	4.81	5.15	8.85
	J01CE	ß-lactamase sensitive penicillins	0.53	0.60	0.47	0.55	0.40	0.59	0.66	0.60	0.71	0.62
	J01CF	ß-lactamase resistant penicillins	0.19	0.18	0.39	0.50	0.18	0.15	0.16	0.22	0.19	0.41
	J01DB	First-generation cephalosporins	1.24	1.26	2.00	1.23	1.01	0.41	1.19	1.23	1.22	1.67
	J01DC	Second-generation cephalosporins	0.63	0.67	0.41	0.49	0.90	0.74	1.61	1.17	0.56	1.34
	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	0.96	0.98	1.37	1.05	0.73	0.39	1.05	1.16	1.29	1.66
	J01FA	Macrolides	3.62	4.04	2.94	3.04	4.08	3.19	4.07	3.78	4.49	5.66
	J01FF	Lincosamides	0.40	0.48	0.53	0.32	0.37	0.34	0.41	0.39	0.30	0.28
	J01GB	Aminoglycosides	NA	NA	NA	NA	< 0.01	NA	NA	NA	NA	NA
	J01MB	Other quinolones, excluding fluoroquinolones	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	J01RA	Sulfonamide combinations, excluding trimethoprim	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
	J01XC	Steroid antimicrobials	< 0.01	< 0.01	NA	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
III	J01AA	Tetracyclines	2.88	3.07	4.20	2.64	2.33	1.62	1.77	2.90	2.91	2.33
	J01EA	Trimethoprim and derivatives	0.04	0.03	0.10	0.01	0.06	0.05	0.05	0.03	0.01	0.11
	J01EB	Short-acting sulfonamides	NA	NA	NA	NA	< 0.01	< 0.01	NA	NA	NA	NA
	J01EC	Intermediate-acting sulfonamides	< 0.01	NA	NA	NA	< 0.01	< 0.01	NA	NA	NA	NA
	J01XE	Nitrofuran derivatives	0.63	0.59	0.99	0.44	0.77	0.29	0.73	0.95	0.74	0.59
	J01XX	Fosfomycin	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
NC	J01XX	Methenamine	0.01	< 0.01	< 0.01	NA	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01
	J01	**Total**	**18.00**	**19.92**	**22.33**	**18.75**	**18.92**	**13.54**	**19.81**	**20.38**	**22.05**	**30.20**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

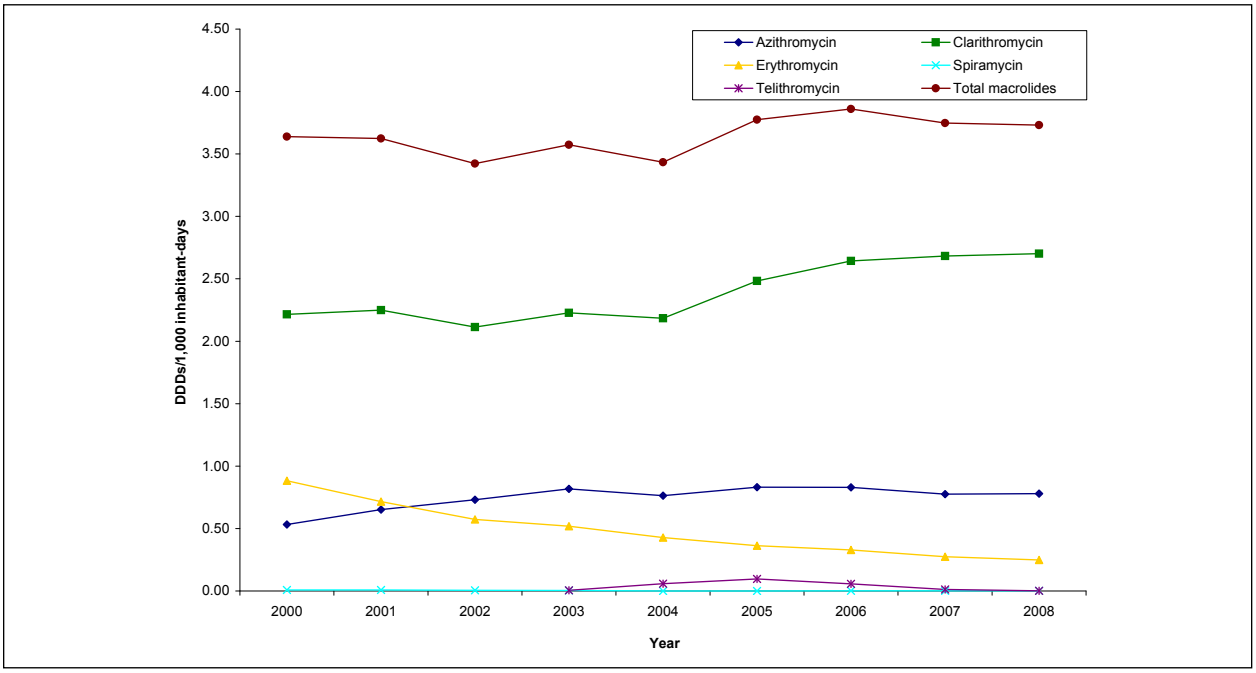
ATC = Anatomical Therapeutic Chemical. DDD = Defined daily dose. NA = Not available. NC = Not classified.

FIGURE 39. Total consumption (DDDs/1,000 inhabitant-days) of oral fluoroquinolones dispensed by retail pharmacies in Canada, 2000-2008.



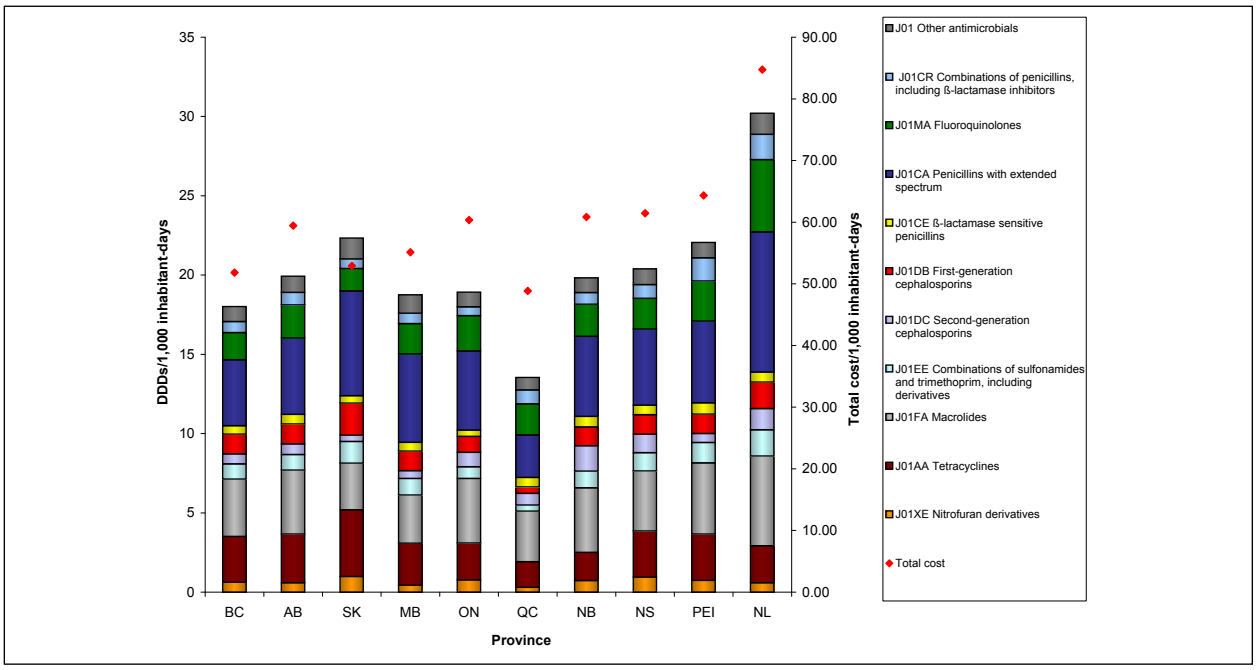
DDD = Defined daily dose.

FIGURE 40. Total consumption of oral macrolides (DDDs/1,000 inhabitant-days) dispensed by retail pharmacies in Canada, 2000-2008.



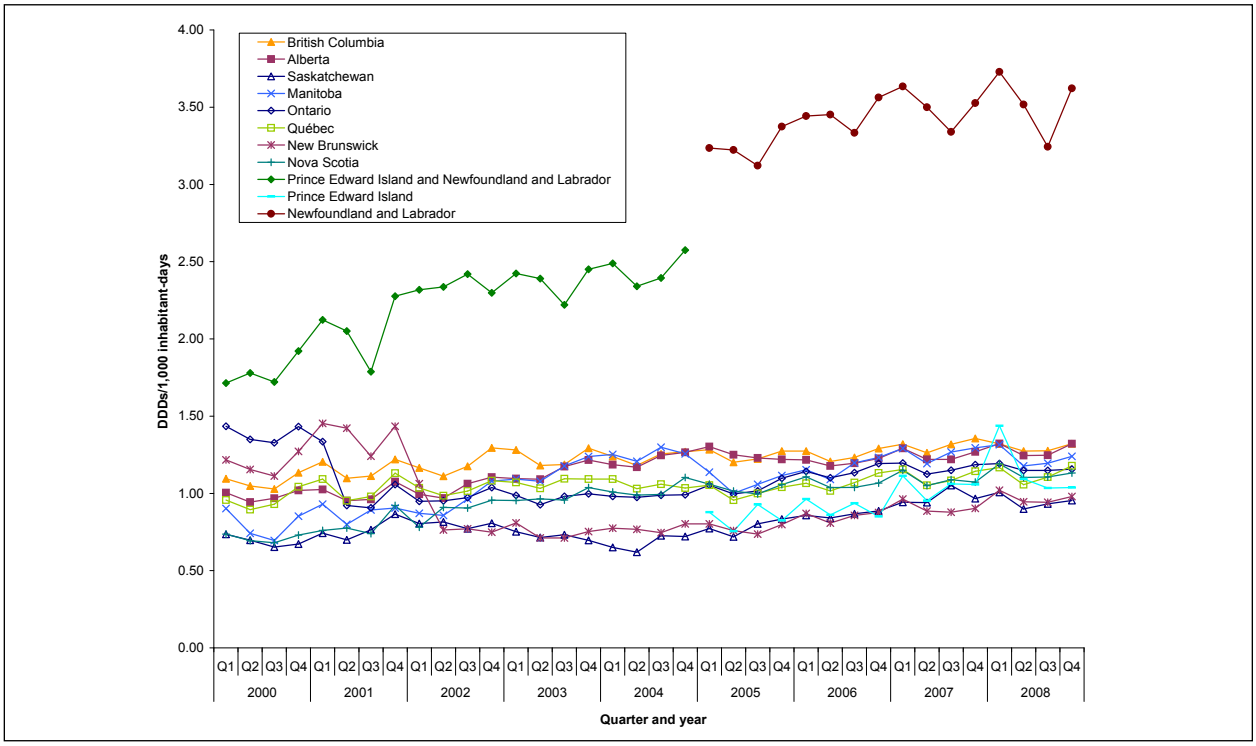
DDD = Defined daily dose.

FIGURE 41. Total consumption (DDDs/1,000 inhabitant-days) and total cost ($/1,000 inhabitant-days) of oral antimicrobials dispensed by retail pharmacies in Canadian provinces, 2008.



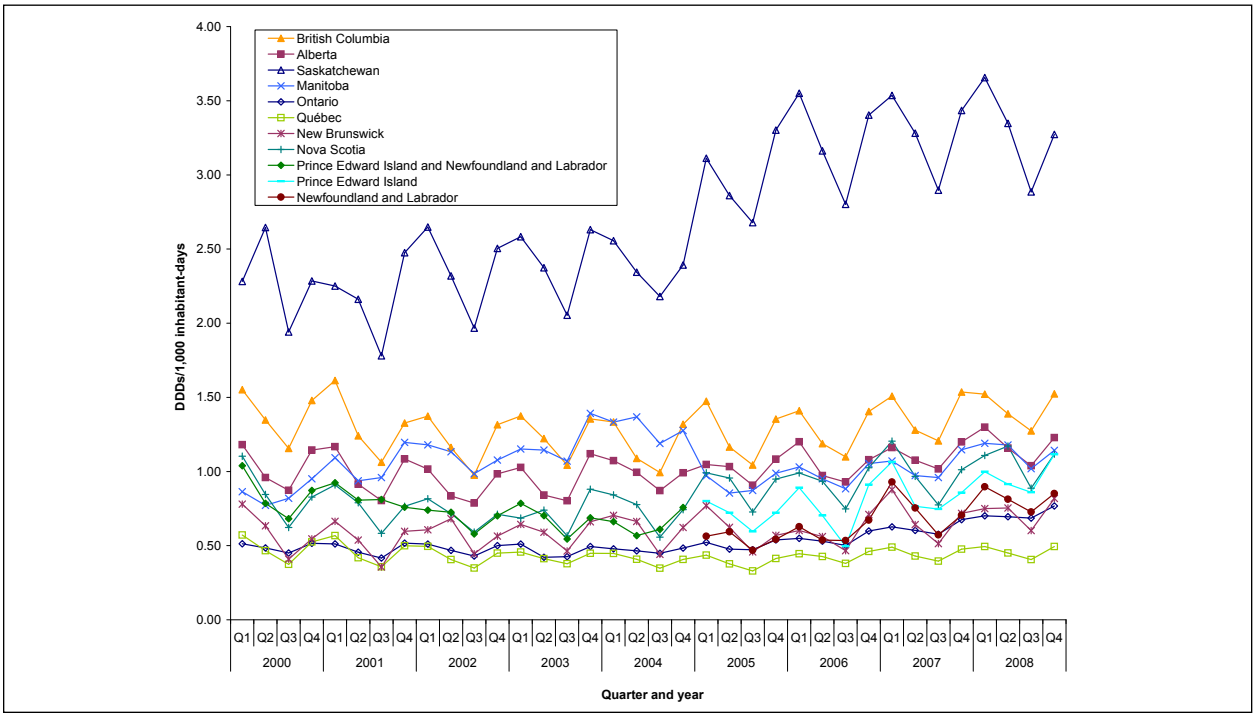
Alphanumeric codes in the legend represent Anatomical Therapeutic Chemical classes of antimicrobials.
DDD = Defined daily dose.

FIGURE 42. Total consumption (DDDs/1,000 inhabitant-days) of oral ciprofloxacin dispensed by retail pharmacies in Canadian provinces, 2000-2008.



Up to 2005, data for Prince Edward Island and for Newfoundland and Labrador are grouped. For 2005 and onward, these data are reported separately.
DDD = Defined daily dose.

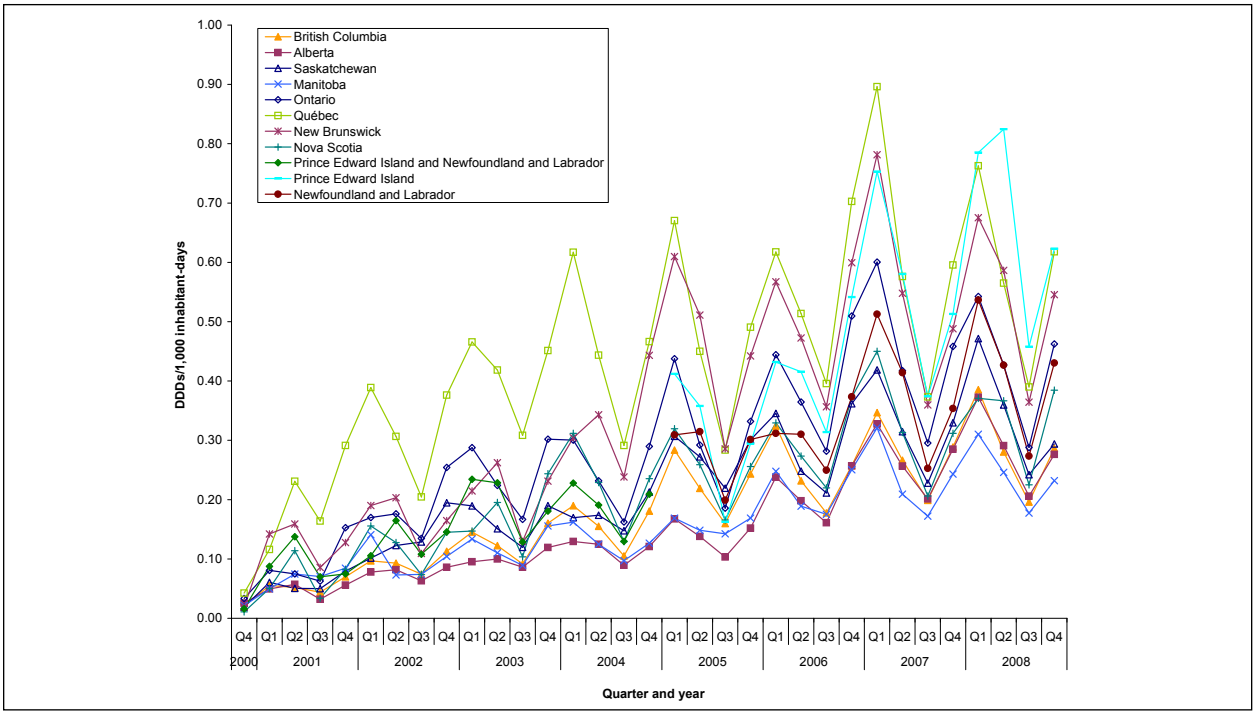
FIGURE 43. Total consumption (DDDs/1,000 inhabitant-days) of oral doxycycline dispensed by retail pharmacies in Canadian provinces, 2000-2008.



Up to 2005, data for Prince Edward Island and for Newfoundland and Labrador are grouped. For 2005 and onward, these data are reported separately.

DDD = Defined daily dose.

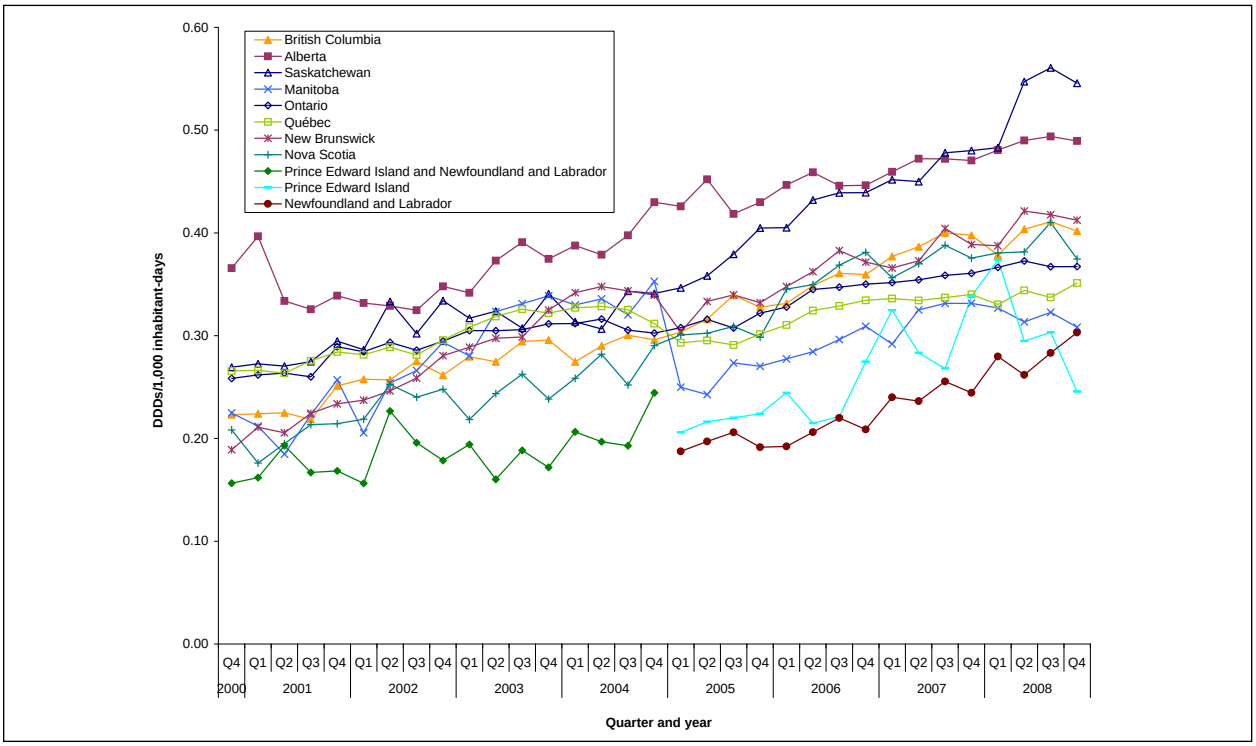
FIGURE 44. Total consumption (DDDs/1,000 inhabitant-days) of oral moxifloxacin dispensed by retail pharmacies in Canadian provinces, 2000-2008.



Up to 2005, data for Prince Edward Island and for Newfoundland and Labrador are grouped. For 2005 and onward, these data are reported separately.

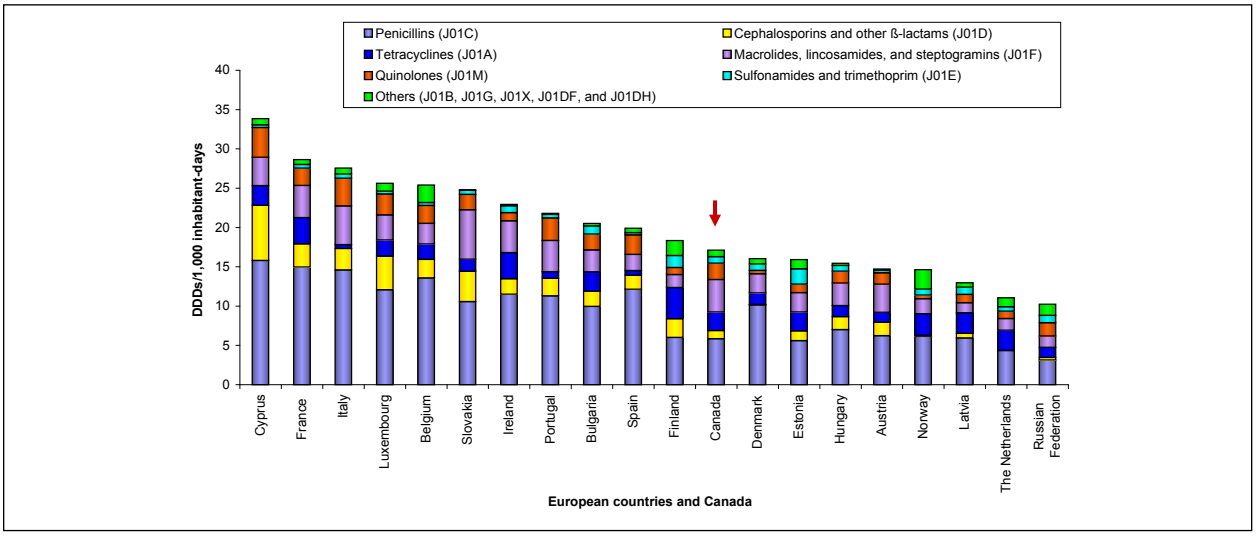
DDD = Defined daily dose.

FIGURE 45. Total consumption (DDDs/1,000 inhabitant-days) of oral clindamycin dispensed by retail pharmacies in Canadian provinces, 2000-2008.



Up to 2005, data for Prince Edward Island and for Newfoundland and Labrador are grouped. For 2005 and onward, these data are reported separately.
DDD = Defined daily dose.

FIGURE 46. Antimicrobial consumption (DDDs/1,000 inhabitant-days) in 19 European countries and Canada; European Surveillance of Antimicrobial Consumption and CIPARS, 2007.



Alphanumeric codes in parentheses represent Anatomical Therapeutic Chemical classes of antimicrobials.
DDD = Defined daily dose.

Farm Surveillance

Pigs

Twenty-one veterinarians representing 96 sentinel swine herds were enrolled in CIPARS *Farm Surveillance* in 2008 (Appendix A). Of these, 20 veterinarians submitted completed questionnaires from 95 herds. Questionnaires provided data regarding herd characteristics (Figures C.1 and C.2, Appendix C), management, and antimicrobial use (AMU) and were administered 3 times per year. At least 3 completed AMU questionnaires were submitted by representatives for 60 participating herds, 2 questionnaires were submitted for 20 herds, and 1 questionnaire was submitted for 15 herds. Antimicrobial use may be underestimated in herds for which 3 completed questionnaires were not submitted in 2008.

The herds were distributed in the following provinces: Alberta, 24 (25%); Saskatchewan, 3 (3%); Manitoba, 7 (7%); Ontario, 24 (25%); and Québec, 27 (28%). For 10 (11%) corporate herds in western Canada, the province was not disclosed to CIPARS staff to maintain producer anonymity. Veterinarians of 47 (50%) herds reported continuous-flow management in the grower-finisher production phase, and veterinarians of 45 (47%) herds reported all-in-all-out management. Three (3%) herds were reported as having more than 1 pig-flow management system over the year. Half of the sentinel herds had a grower-finisher barn capacity that exceeded 1,700 pigs.

Canada Overall

Data regarding antimicrobial use practices were available for all herds. Ninety-five percent (90/95) of the herds reported using antimicrobials in the grower-finisher production phase and 5% (5/95) of the herds reported no antimicrobial use in the grower-finisher production phase. Among all participating herds, AMU was more common via feed (79%, 75/95) and injection (61%, 58/95) than by water (28%, 27/95).

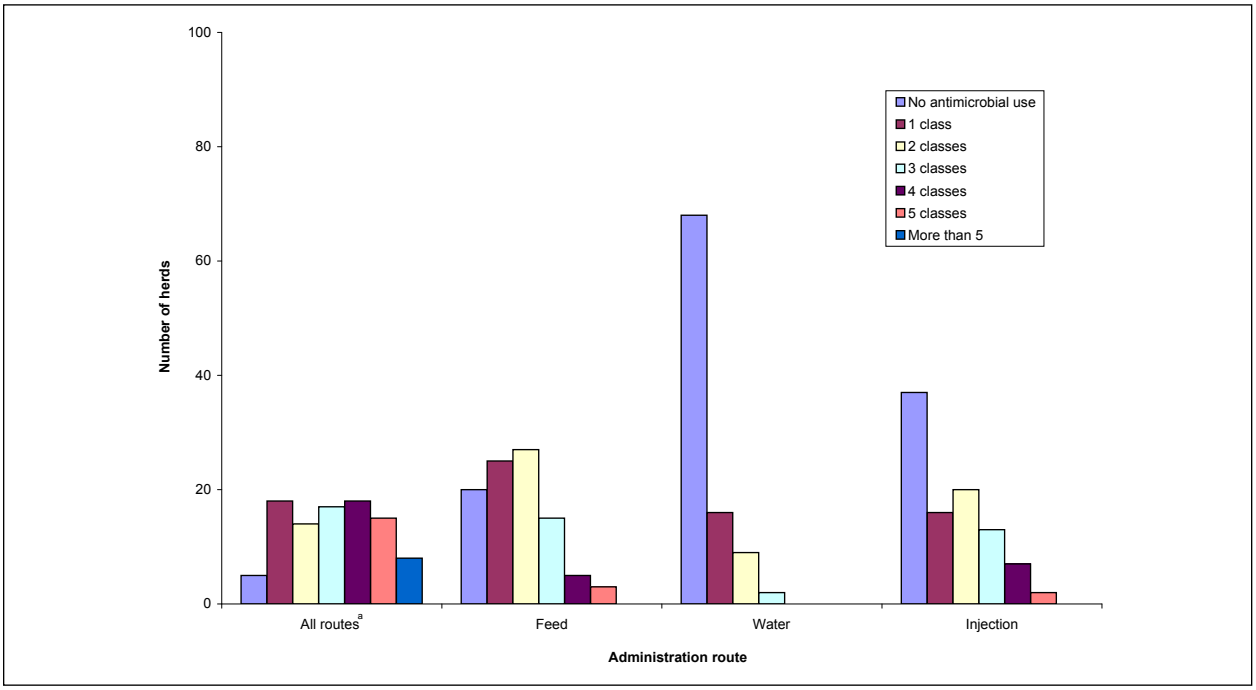
Representatives of 61% (58/95) of the herds reported the use of antimicrobials from 3 or more classes (range, 0 to 6; Figure 47). The most commonly used antimicrobial class was the penicillins (68%, 65/95; Figure 48 and Table 28). Antimicrobials in the macrolide class were the most common antimicrobials administered through feed and were most commonly used to treat enteric disease or promote growth (Figure 49 and Figure 50). Use of macrolides and/or lincosamides via feed often persisted until pigs were close to market weight. Penicillins were the most common antimicrobials administered through water. These antimicrobials were administered to pigs of all weights and were predominantly used to prevent disease or treat respiratory disease (Figure 51 and Figure 52). Penicillins were also the most common drugs administered via injection (Figure 48). The 2 primary reasons for penicillin use via injection were to treat respiratory disease and lameness (Figure 53).

Injectable ceftiofur, an extended-spectrum cephalosporin, was used in 21% (20/95) of herds. Ceftiofur is the only antimicrobial used in these pig farms that is classified by Health Canada's Veterinary Drugs Directorate as a Category I antimicrobial (Table 29). Compared with the use of ceftiofur in 2007 (29%, 29/100), the reported use of ceftiofur in 2008 represents an 8% decrease. Ceftiofur was used in the treatment of respiratory disease, lameness, enteric disease, and other unspecified conditions (Figure 53).

In 2008, the only Category I antimicrobial used in grower-finisher pig herds was injectable ceftiofur (21% [20/95] of herds). No herd representatives reported virginiamycin use. The most commonly used antimicrobials overall were penicillins, which were administered primarily via drinking water or injection. Macrolides were the most common antimicrobials administered through feed. There were 5 herds in which no antimicrobials were used by any route in the grower-finisher production stage.

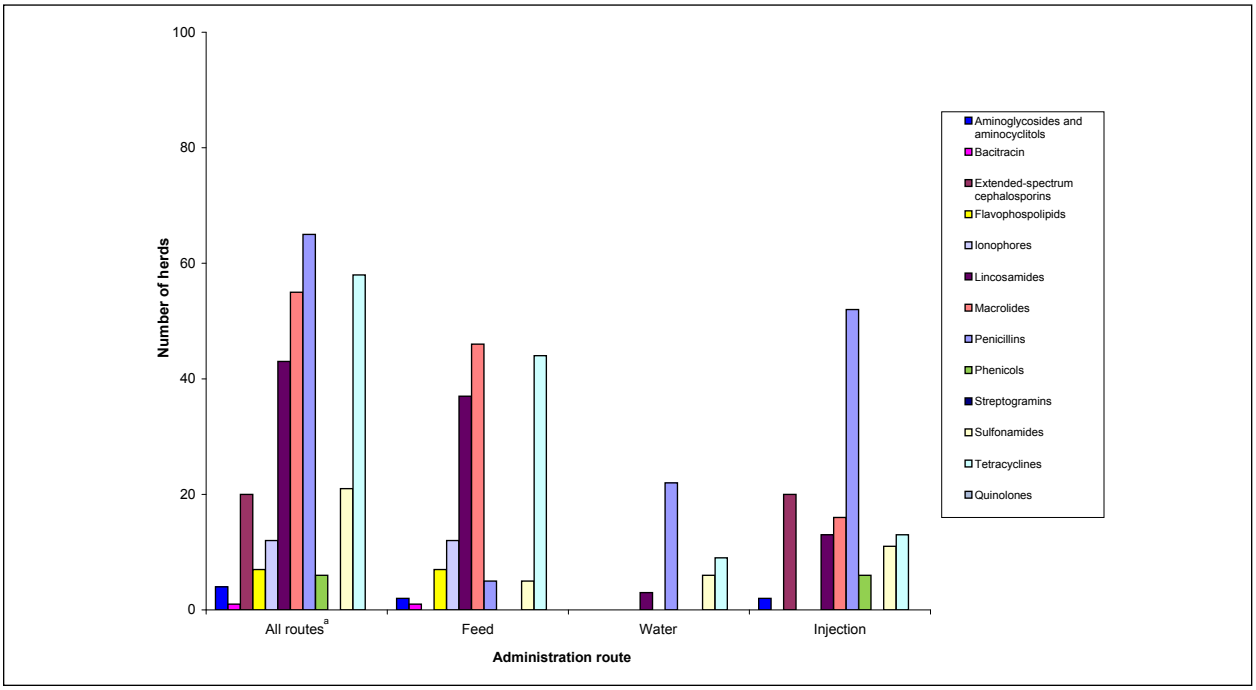
[1] Other animal demographic information is presented in Table C.9 and Table C.10, Appendix C.

FIGURE 47. Number of swine herds with reported use of no antimicrobials, a single antimicrobial class, or multiple antimicrobial classes, by administration route (n = 95); *Farm Surveillance*, 2008.



[a] Values in this category represent the sum of antimicrobial classes reportedly used in each herd, counting each class no more than once regardless of number of administration routes reported.

FIGURE 48. Number of swine herds with reported use of specific antimicrobial classes, by administration route (n = 95); *Farm Surveillance*, 2008.



[a] Herds with reported use of an antimicrobial class by feed, water, injection, or any combination of these routes are included in this category.

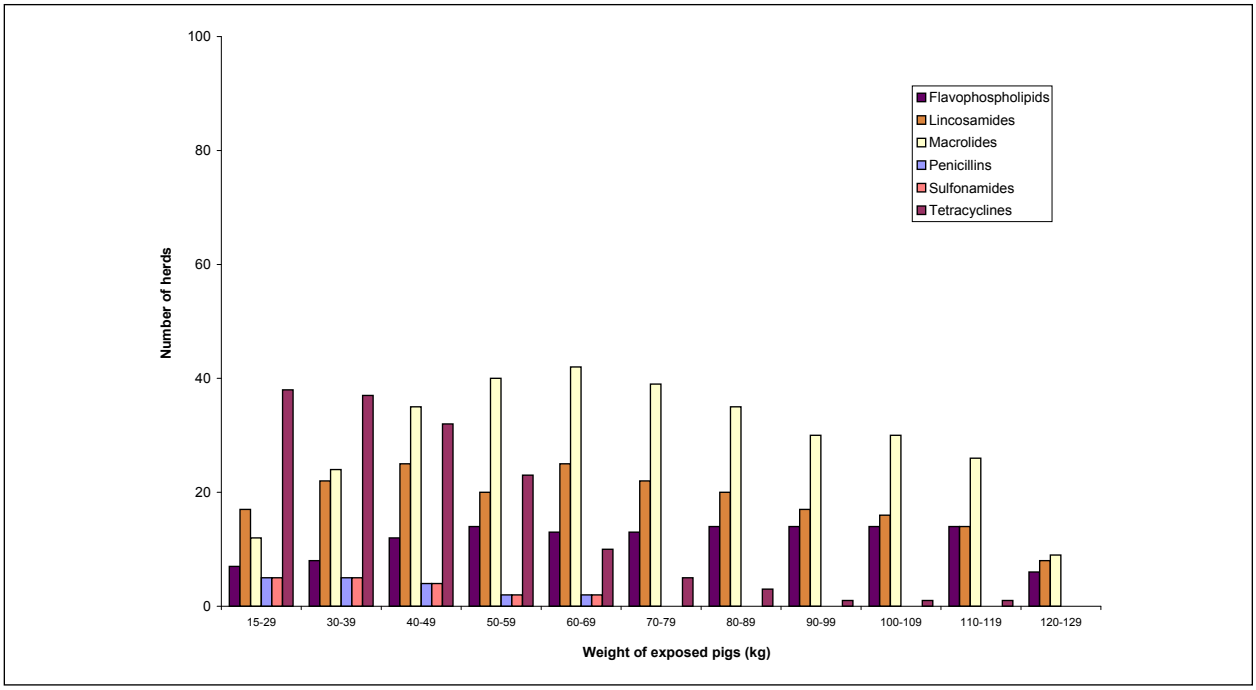
TABLE 28. Number of swine herds with reported use of specific active antimicrobial ingredients, by administration route (n = 95); *Farm Surveillance*, 2008.

	Antimicrobial class	Antimicrobial	Administration route			
			Any route[a]	Feed	Water	Injection
I	Extended-spectrum cephalosporins	Ceftiofur	20	0	0	20
II	Aminoglycosides	Neomycin	1	1	0	0
	Lincosamides	Lincomycin	40	34	3	11
		Tiamulin	10	6	0	4
	Macrolides	Erythromycin	1	0	0	1
		Tulathromycin	6	0	0	6
		Tylosin	52	46	0	11
	Penicillins	Amoxicillin	2	0	2	0
		Ampicillin	3	0	0	3
		Penicillin G	64	5	15	52
		Phenoxymethyl penicillin	6	0	6	0
	Streptogramins	Virginiamycin	0	0	0	0
	Trimethoprim-sulfamethoxazole	Trimethoprim-sulfadoxine	13	0	3	11
III	Aminoglycosides	Spectinomycin	3	1	0	2
	Bacitracins	Bacitracin	1	1	0	0
	Phenicols	Florfenicol	6	0	0	6
	Sulfonamides	Sulfonamide (unspecified)	8	5	3	0
	Tetracyclines	Chlortetracycline	45	43	3	0
		Oxytetracycline	14	1	0	13
		Tetracycline hydrochloride	7	0	7	0
IV	Flavophospholipids	Bambermycin	7	7	0	0
	Ionophores	Salinomycin	12	12	0	0

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

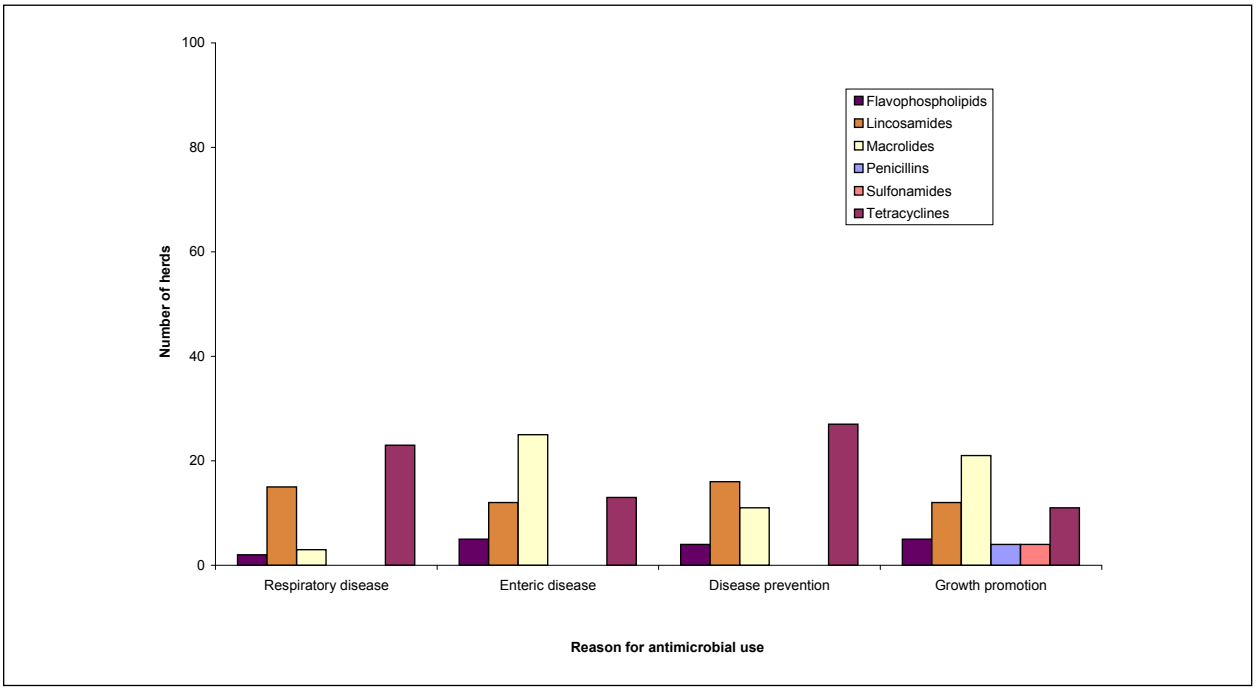
[a] Herds with reported use of an antimicrobial class by feed, water, injection, or any combination of these routes are included in this category.

FIGURE 49. Number of swine herds with reported use of specific antimicrobial classes in feed, by weight category of pigs (n = 95); *Farm Surveillance*, 2008.



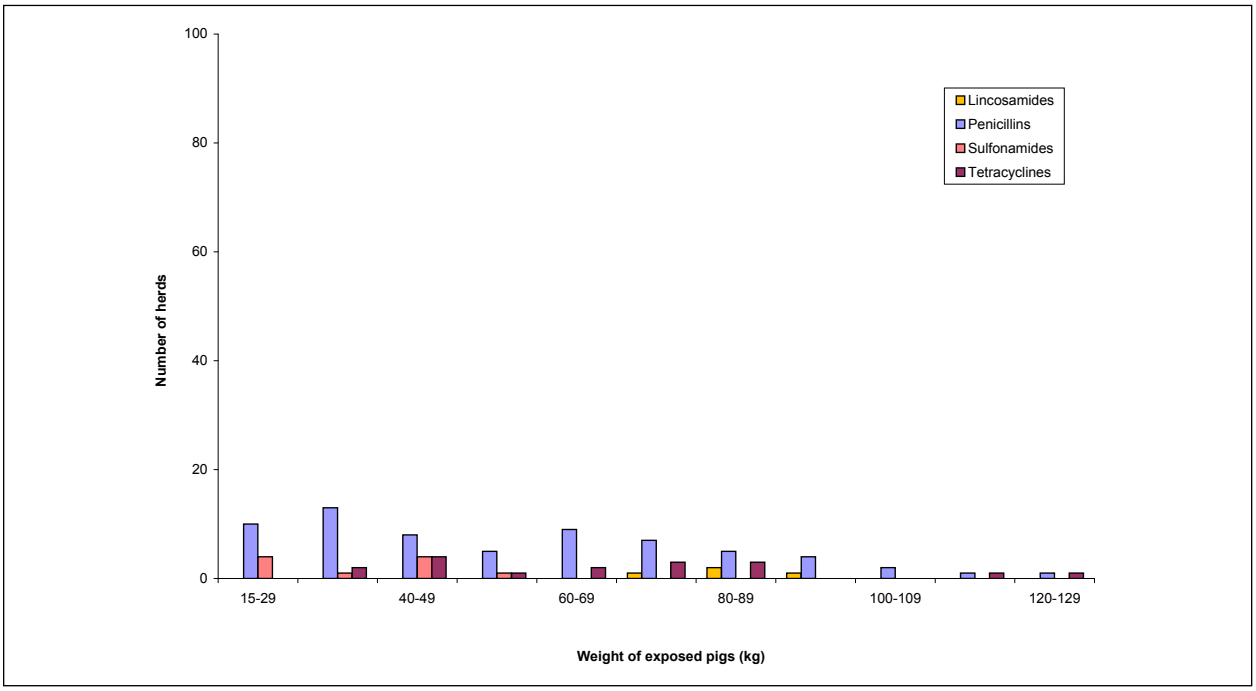
Data regarding antimicrobial classes used in feed in less than 5 herds are not presented.

FIGURE 50. Number of swine herds with reported use of specific antimicrobial classes in feed, by reason for use (n = 95); *Farm Surveillance*, 2008.



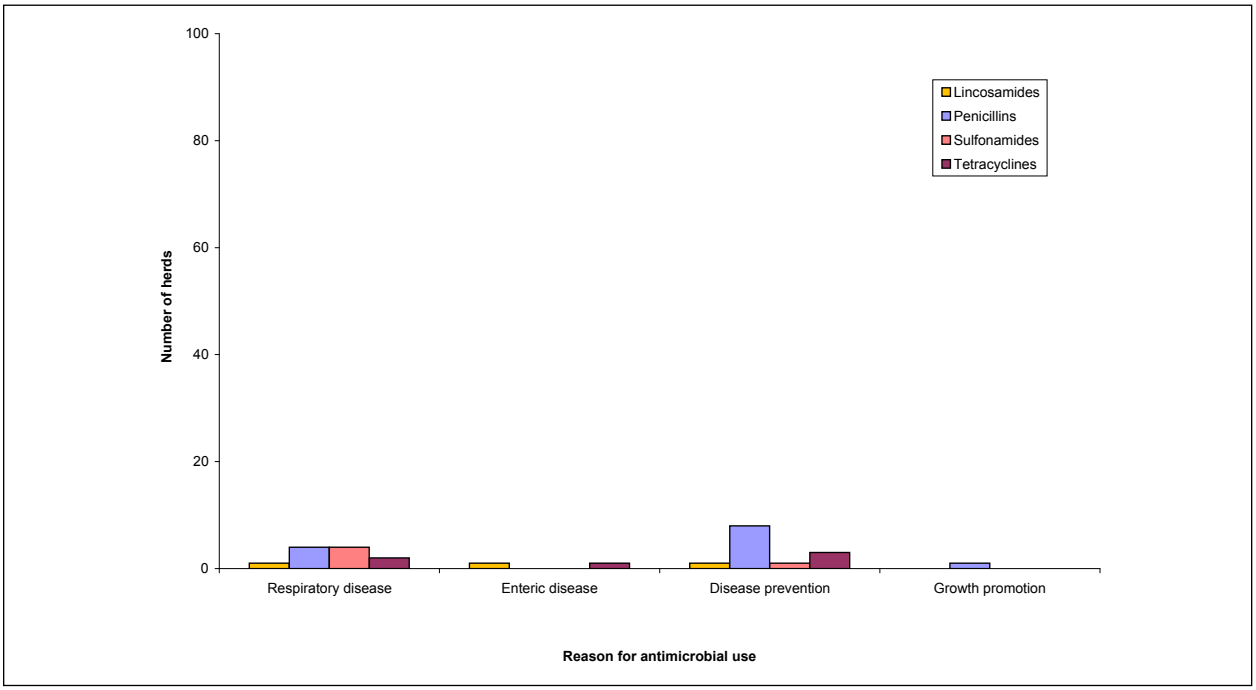
Data regarding antimicrobial classes used in feed in less than 5 herds are not presented.

FIGURE 51. Number of swine herds with reported use of specific antimicrobial classes in water, by weight category of pigs (n = 95); *Farm Surveillance*, 2008.



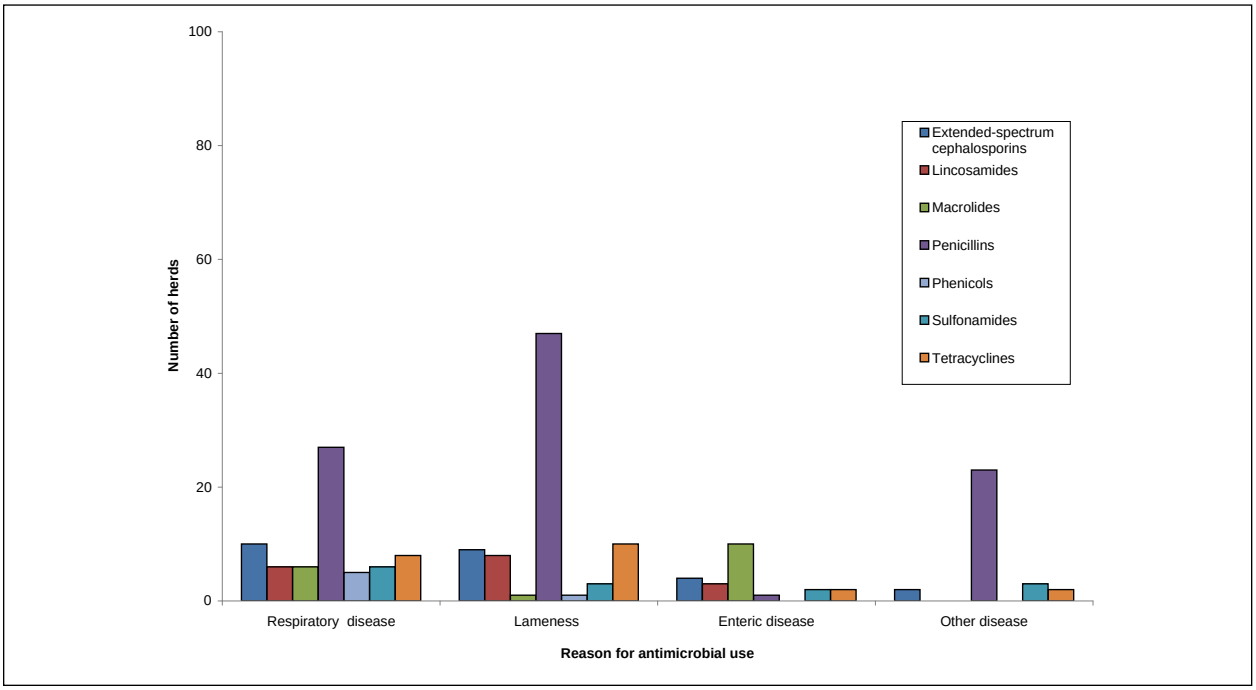
Data regarding antimicrobial classes used in water in less than 5 herds are not presented.

FIGURE 52. Number of swine herds with reported use of specific antimicrobial classes in water, by reason for use (n = 95); *Farm Surveillance*, 2008.



Data regarding antimicrobial classes used in water in less than 5 herds are not presented.

FIGURE 53. Number of swine herds with reported use of specific antimicrobial classes via injection, by reason for use (n = 95); *Farm Surveillance*, 2008.



Canadian Animal Health Institute

The Canadian Animal Health Institute (CAHI) is the trade association representing the companies that manufacture and distribute drugs for administration to food, sporting, and companion animals in Canada. The association estimates that its members' sales represent over 95% of all sales of licensed animal pharmaceutical products in Canada. CAHI coordinates electronic collection of data from its members and 1 non-member on the total kilograms of antimicrobials distributed by Canadian companies. Data collection and analysis are performed by a third party, Impact Vet.[1]

Acquired data on active ingredients were aggregated and provided to the Public Health Agency of Canada by CAHI (Table 29). Data regarding all licensed antimicrobials for use in food, sporting, and companion animals and fish were included. These data do not represent actual antimicrobial use in a given year; rather, they reflect the volume of antimicrobials distributed by manufacturers. Distribution values should approximate amounts used, particularly when data from more than 1 year are included. However, when data from only 1 year are included, distribution values may vary from amounts actually used because of the time lag between distribution and actual use, as well as stockpiling of antimicrobials at various points in the distribution system. The data do not include antimicrobials imported for personal use (own use import) under the personal-use provision of the federal *Food and Drugs Act & Regulations*, nor do they include active pharmaceutical ingredients, which are drugs imported in non-dosage form and compounded by a licensed pharmacist or veterinarian and used in veterinary medicine and food-animal production. See the 2006 CIPARS report for more information.[2]

The CAHI data on the distribution of antimicrobials for use in animals provide a context through which to interpret other data on antimicrobial use in animals generated through research and farm data collection. They also provide a means to monitor gross temporal changes in antimicrobial use in animals.

CAHI's data collection process resulted in several changes to the categorization of specific antimicrobials (in comparison to 2006 and 2007). The major changes are outlined below:

- The cephalosporin class was not reported separately. One 1st generation cephalosporin was included in "ß-lactams." The remainder, a 1st generation and a 3rd generation cephalosporin, were included in "Other antimicrobials."
- "Amphenicols" were reported as a separate category (previously included in "Other antimicrobials").
- "Bacitracins" were grouped with "Macrolides and Pleuromutilins" (previously included in "Other antimicrobials").
- "Nitroimidazoles" were grouped with "Ionophores, chemical coccidiostats and arsenicals" (previously included in "Other antimicrobials").
- "Neomycin" (an aminoglycoside) was moved to "Other antimicrobials" (previously included in "Aminoglycosides").

These changes in aggregation are important to keep in mind when making year-to-year comparisons. Overall, the total kilograms of active ingredient distributed for sale by Canadian companies decreased by 8.52% relative to the 2006 total and by less than 1% relative to the 2007 total. In terms of Category I antimicrobials, the quantity of fluoroquinolones distributed for use in animals in 2008 decreased by 30.38% relative to the 2006 total and by 7.15% relative to the 2007 total. Reasons for these decreases are unknown but may be related to major livestock production changes in Canada (Appendix C, Tables C.9 and C.10).

In 2008, the total kilograms of antimicrobials distributed for sale by CAHI member companies decreased by 8.52%, as a percentage of the 2006 total and by less than 1% as a percentage of the 2007 total. The quantity of fluoroquinolones distributed for use in animals in 2008 decreased by 30.38% relative to the 2006 total and by 7.15% relative to the 2007 total.

[1] Division of AgLine/TI Communications Ltd. See: www.impactvet.com. Accessed August 2009.

[2] See: www.phac-aspc.gc.ca/cipars-picra/2006-eng.php. Accessed December 2010.

TABLE 29. Quantity of antimicrobials in dosage form distributed in Canada for use in animals; Canadian Animal Health Institute, 2006-2008.

Antimicrobial class aggregation	Total active ingredients (kg)			Percentage change from 2006 to 2008	Percentage change from 2007 to 2008
	2006	2007	2008		
Aminoglycosides	5,121.60	4,302.20	5,816.88	13.58%	35.21%
Amphenicols	NA	NA	3,242.03	NA	NA
β-lactams (2006 and 2007)	58,538.00	52,594.00	NA	NA	NA
β-lactams (2008)	NA	NA	109,152.97	NA	NA
Cephalosporins	702.00	850.00	NA	NA	NA
Fluoroquinolones	591.00	443.10	411.44	-30.38%	-7.15%
Ionophores, chemical coccidiostats, and arsenicals (2006 and 2007)	455,753.00	445,952.00	NA	NA	NA
Ionophores, chemical coccidiostats, arsenicals, and nitroimidazoles (2008)	NA	NA	472,384.36	NA	NA
Lincosamides	67,825.30	55,872.30	41,222.12	-39.22%	-26.22%
Macrolides and pleuromutilins (2006 and 2007)	136,496.50	118,724.80	NA	NA	NA
Macrolides, pleuromutilins, and bacitracins (2008)	NA	NA	210,868.75	NA	NA
Tetracyclines	847,280.60	753,168.40	680,601.15	-19.67%	-9.63%
Trimethoprim and sulfonamides	50,789.00	38,961.00	59,165.54	16.49%	51.86%
Other antimicrobials (2006 and 2007)	143,029.00	146,879.80	NA	NA	NA
Other antimicrobials (2008)	NA	NA	32,706.00	NA	NA
Total	**1,766,126.00**	**1,617,747.60**	**1,615,571.23**	**-8.52%**	**-0.13%**

Values do not include own use imports or active pharmaceutical ingredients used in compounding.

In comparison with antimicrobial groupings used in previous years, CAHI's 2008 data were provided to CIPARS under different aggregations. The cephalosporin class was not reported separately – one 1st generation cephalosporin was included in the "ß-lactams" class and the remainder, a 1st generation and a 3rd generation cephalosporin, were included in "Other antimicrobials." "Amphenicols" were reported as a separate category (previously included in "Other antimicrobials"). "Bacitracins" were grouped with the "Macrolides and Pleuromutilins" (previously included in "Other antimicrobials"). "Nitroimidazoles" were grouped with the "Ionophores, chemical coccidiostats and arsenicals" (previously included in "Other antimicrobials"). "Neomycin" (an aminoglycoside) was moved to "Other antimicrobials" (previously in "Aminoglycosides").

"Other antimicrobials" included: clavulanic acid, bambermycin, ceftiofur, cephapirin, neomycin, nitrofurantoin, nitrofurazone, novobiocin, polymixin, sodium iodide, and virginiamycin.

NA = Not available.

Box 1. Antimicrobial-resistant bacteria in companion animals in Ontario.

Several CIPARS-affiliated research projects have been undertaken to investigate the existence of antimicrobial-resistant bacteria in dogs and cats in Ontario. The findings of 3 recent studies are described here briefly.

Occurrence of antimicrobial-resistant bacteria in healthy dogs and cats presented to private veterinary hospitals in Southern Ontario: a preliminary study.

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The prevalence and patterns of antimicrobial susceptibility of fecal bacteria were determined for healthy dogs (n = 188) and cats (n = 39) from private veterinary hospitals in Southern Ontario. The animals had no recent exposure to antimicrobials. The study was carried out in the summer of 2002. *Escherichia coli* was recovered from all dogs and cats. On the other hand, no *Salmonella*, extended-spectrum ß-lactamase-producing *E. coli*, methicillin-resistant *Staphylococcus aureus*, or methicillin-resistant *Staphylococcus pseudintermedius* were recovered.

The prevalence of antimicrobial resistance in *E. coli* was as follows: ampicillin—dogs, 13% and cats, 4%; cephalothin—dogs, 13% and cats, < 1%; streptomycin—dogs, 17% and cats, 2%; and tetracycline—dogs, 11% and cats, 2%. Eleven percent of dogs and 15% of cats had *E. coli* isolates that were resistant to at least 2 antimicrobials. Cephamycinase (bla_{CMY-2}) producing *E. coli* were cultured from the feces of 2 dogs. The prevalence of resistance in commensal *E. coli* from this group of animals was lower than that previously reported for companion animals: however, a small percentage of dogs may be a reservoir for bla_{CMY-2} *E. coli*.

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Pet-related management factors associated with the presence of *Salmonella* in the feces of dogs in Ontario.

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Between October 2005 and May 2006, 138 dogs from 84 households in Ontario were enrolled in a cross-sectional study. The goal of the study was to identify pet-related management factors associated with the presence of *Salmonella* in feces of dogs from volunteer households. Twenty-three percent (32/138) of dogs had at least 1 fecal sample with positive results for *Salmonella*, and 25% (21/84) of the households had at least 1 dog shedding *Salmonella*. Twelve serovars of *Salmonella* were identified. The most common were *S.* Typhimurium (33%), *S.* Kentucky (15%), *S.* Brandenburg (15%), and *S.* Heidelberg (13%).

Important risk factors associated with *Salmonella* shedding included having contact with livestock, receiving a probiotic in the month prior to sample collection, consuming a commercial or homemade raw food diet, consuming raw meat and eggs, and having more than 1 dog in the household. Antimicrobial susceptibility testing of the *Salmonella* isolates has been completed and epidemiological analyses are in progress.

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Box 1 (continued). Antimicrobial-resistant bacteria in companion animals in Ontario.

Pet-related management factors associated with the presence of *Campylobacter*, *Salmonella*, and *Giardia* in the feces of pet dogs visiting veterinary clinics in Ontario.

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From July 2008 until May 2009, 240 dogs from 7 veterinary clinics in the Region of Waterloo, Ontario were enrolled in a cross-sectional study. The purpose of this study was to identify pet-related management factors that may be associated with the presence of *Campylobacter*, *Salmonella*, and *Giardia* in the feces of dogs visiting veterinary clinics. Twenty-two percent (52/240) of the dogs had at least 1 fecal sample positive for *Campylobacter*. Among *Campylobacter*-positive dogs, 89% were positive for *C. upsaliensis*, 14% were positive for *C. jejuni*, and 1 dog had both *C. upsaliensis* and *C. jejuni*. Six percent (14/240) of the dogs had at least 1 sample positive for *Giardia*, and 2% (4/240) had at least 1 sample positive for *Salmonella*.

Significant risk factors for a dog testing positive for any species of *Campylobacter* included being less than 1 year of age, participating in a group activity (e.g. obedience or agility training), and having homemade cooked food as their diet or added to their diet. Treatment with antimicrobials in the month prior to sample collection was negatively associated with *Campylobacter* shedding. Important risk factors for a dog testing positive for *Giardia* included being less than 1 year of age, living in a rural small town, having a previous enteric illness (infection with *Giardia*, *Salmonella*, *Campylobacter*, or *Clostridium difficile*), and drinking well water. Antimicrobial susceptibility testing of the *Campylobacter*- and *Salmonella*-positive samples has been completed, and antimicrobial resistance patterns will be compared with those of generic *Escherichia coli* recovered from the same dogs.

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Box 2. Prevalence of selected veterinary and zoonotic pathogens isolated from environmental samples collected from veterinary clinics in Southern Ontario.

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The importance of hospital-based infection control in veterinary medicine is increasingly recognized, whereas the role of the clinic environment in hospital-acquired infections is largely unknown. The purpose of this study was to evaluate environmental contamination with *Escherichia coli* and other selected veterinary and zoonotic pathogens in community veterinary hospitals in Southern Ontario. Over the study period (May through August, 2005), environmental samples were collected from 101 companion animal hospitals. The proportion of hospitals with positive environmental swabs was as follows: *E. coli*, 92%; *Clostridium difficile*, 58%; methicillin-resistant *Staphylococcus aureus* (MRSA), 9%; bla_{CMY-2} *E. coli*, 9%; methicillin-resistant *Staphylococcus pseudintermedius*, 7%; and *Salmonella*, 2%. Vancomycin-resistant *Enterococcus*, canine parvovirus, and feline calicivirus were not isolated. The prevalence of antimicrobial resistance in the *E. coli* isolates was low. All *Salmonella* isolates were susceptible to all antimicrobials evaluated. Susceptibility testing was not performed on the other bacterial isolates.

This study demonstrated that there is an environmental reservoir of pathogens in veterinary hospitals. Important potential veterinary and human pathogens were recovered including Canadian epidemic strains MRSA-2, MRSA-5, and *C. difficile* ribotype 027. Additional studies are required to characterize risk factors associated with hospital-acquired infections in companion animals, including the role of the environment.

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Box 3. Antimicrobial use and resistance on sheep farms in Ontario.

Sheep are considered a minor food animal commodity in Canada, and few antimicrobials are approved for use in sheep and lambs in Canada. Consequently, it was hypothesized that much antimicrobial use would be extra-label drug use (ELDU), which is the use of a drug in any manner inconsistent with label instructions. This antimicrobial use practice in livestock may have public health implications. An antimicrobial use and resistance project was therefore initiated to prospectively gather antimicrobial use and resistance data from sheep farms in Ontario. Each component of this project is presented independently below.

Antimicrobial use on sheep farms in Ontario, Canada.

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Producers from 49 lamb-producing sheep farms in Ontario maintained antimicrobial treatment records for a 12-month study period between 2006 and 2008. Farm-level data (i.e. animal management practices and inventories of the number of lambs, ewes, and rams on the farm) were collected via a questionnaire administered to producers at the beginning and end of the study period. Antimicrobial exposure rates (AERs) and rates of extra-label drug use (ELDU; indication, dose or sheep class inconsistent with label instructions) were calculated by use of treatment records and sheep inventories. Treatment-level and farm-level variables were investigated for associations with rates of antimicrobial use by means of Poisson rate regression analysis fit with a generalized estimating equation to control for clustering at the farm level.

Overall, the mean AER for lambs and adult sheep was approximately 66 sheep-days treated per 1,000 sheep-days at risk. Chlortetracycline, an in-feed antimicrobial approved for use in lambs to prevent losses from enterotoxaemia, had the highest mean AER in both lambs (32.7 sheep-days treated per 1,000 sheep-days at risk) and adult sheep (10.6 sheep-days treated per 1,000 sheep-days at risk). Other antimicrobials with high AERs included long-acting oxytetracycline (not licensed for use in sheep) and short- and long-acting penicillin (both products licensed for use in sheep). Among sheep treated with a licensed antimicrobial, on average, the approved product was used in an extra-label manner in 811.6 sheep-days per 1,000 sheep-days treated. The mean rate of using an antimicrobial not licensed for any use in sheep was 191.2 sheep-days per 1,000 sheep-days treated with any antimicrobial. In summary, approximately 20% of use involved a non-licensed product and approximately 80% of licensed antimicrobial use involved some form of ELDU.

Commonly reported diseases such as respiratory illnesses, wounds/infections, or non-specific disease states (e.g. depressed, off feed, or febrile) were significantly ($P \leq 0.05$) associated with a lower AER in both lambs and adult sheep. Treatment of non-specific disease, mastitis/udder conditions, and ewes post-lambing were significantly associated with lower rates of non-licensed antimicrobial use in all sheep. Less commonly reported disease states (e.g. abortion or gastrointestinal problem) were significantly associated with higher rates of non-licensed use. These results suggest that the need to treat less common diseases is driving ELDU in sheep in Ontario, presumably because the less common the disease, the less likely it is to be included as a labeled use for any antimicrobial.

Direct comparison of ELDU rates could not be made because of limited documentation in other species. However, the results presented here will be useful in determining whether public health concerns about antimicrobial use in Ontario sheep are warranted and in the development of drug use and licensure strategies for the Canadian sheep industry.

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Box 3 (continued). Antimicrobial use and resistance on sheep farms in Ontario.

Prevalence of antimicrobial resistance among *Escherichia coli*, *Salmonella*, and *Campylobacter* isolated from Ontario sheep.

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Inventories and treatment records for 49 Ontario sheep flocks, including 1 sheep feedlot, were maintained for a 12-month study period between 2006 and 2008. At the initial and final visits, pooled fecal samples were collected from 5 animals from each of 2 groups: weaned lambs and adult ewes. The samples were processed for culture of generic *Escherichia coli*, *Salmonella*, and *Campylobacter*, and all bacterial isolates were subjected to antimicrobial susceptibility testing. Preliminary analysis revealed the prevalence and type of resistance detected at the 2 collection times were similar. Therefore, only the results from the final farm visits are presented here.

A total of 137 pooled fecal samples were collected from 48 flocks. Fecal samples were not collected from 1 farm at the final visit because of flock health problems. All pooled samples had positive culture results for *E. coli*, and 3 isolates per sample were selected for antimicrobial susceptibility testing (n = 411 isolates). Fourteen percent (56/411) of *E. coli* isolates were resistant to at least 1 antimicrobial. Resistance to tetracycline was detected in 13% of isolates tested, resistance to streptomycin in 3%, and resistance to sulfisoxazole in 3%. One percent or less of isolates were resistant to each of ampicillin, kanamycin, trimethoprim-sulfamethoxazole, and chloramphenicol. Multidrug resistance among *E. coli* isolates was low (5%), and no resistance was detected to antimicrobials classified as Category I (Very High Importance in Human Medicine). Only 2 of the pooled fecal samples yielded *Salmonella*: 1 *S.* Enteritidis isolate and 1 *Salmonella* IIIb 61:k1,5,7 isolate. Neither *Salmonella* isolate was resistant to the antimicrobials tested. The prevalence of *Campylobacter* was 62% (85/137). Of 85 isolates (1 isolate per positive sample), 86% were *C. jejuni*, 11% were *C. coli*, 1% were *C. lari*, and 2% were other *Campylobacter* species. Of 82 *Campylobacter* isolates tested for antimicrobial susceptibility, 53% were resistant to 1 or more antimicrobials. Resistance to tetracycline was detected in 41% of isolates tested, to nalidixic acid in 4%, and to ciprofloxacin in 2%. One percent of isolates were resistant to each of azithromycin, clindamycin, erythromycin, and telithromycin. Little multidrug resistance (4%) was detected among *Campylobacter* isolates. Further analyses will examine associations between antimicrobial use and resistance in the *E. coli* and *Campylobacter* isolates collected from Ontario sheep flocks.

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Box 4. Prevalence of antimicrobial-resistant bacteria in retail meat from a Northern Ontario First Nations community.

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Antimicrobial resistance is a critical issue in global healthcare and the transmission of resistant bacteria through the food supply is a growing concern. Although there are documented food- and waterborne outbreaks in First Nations communities, rates of sporadic illness and detection of resistance in food- and waterborne bacteria (i.e. *Salmonella*, *Campylobacter*, and *Escherichia coli*) in humans and via the food supply have not been studied specifically in First Nations communities. As such, a pilot retail meat surveillance project, following the methods established by the CIPARS, was initiated in September 2007 in a remote Northern Ontario First Nations community.

The community was only accessible by plane, but road access was possible for 6 to 8 weeks during the winter. Samples of meat were purchased from the local grocery store, packaged, and shipped by the field worker. Samples were received within 24 hours after the date they were sent from the community and were processed for culturing of *E. coli* and *Salmonella* at the Canadian Research Institute for Food Safety, University of Guelph. A portion of each chicken sample was sent to the Laboratory Services Division, University of Guelph for *Campylobacter* isolation. *Salmonella* and *E. coli* isolates were sent to the Laboratory for Foodborne Zoonoses (LFZ) in Guelph, Ontario for antimicrobial susceptibility testing (broth microdilution method) and serotyping/ phage typing for *Salmonella*. *Campylobacter* isolates were sent to the LFZ in Saint-Hyacinthe, Québec for susceptibility testing (broth microdilution method). Eighty frozen chicken, pork, and beef samples were collected between 2007 and 2008.

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Box 5. Antimicrobial-resistant bacteria isolated from wild small mammals in Ontario.

The prevalence of enteric bacteria and antimicrobial resistance has, in general, been well studied in humans and livestock. However, little work has focused on the presence of antimicrobial-resistant bacteria in free-living, wild animals. To determine whether wildlife play a role in the maintenance and dissemination of these bacteria, CIPARS has entered into several research collaborations with the University of Guelph. The results of 1 study are presented below. Other projects investigating antimicrobial resistance in wildlife are currently underway. Together, these studies will provide essential information that will improve our understanding of the role of wildlife in the spread of antimicrobial resistance among bacteria in the environment and of the potential public health risk posed by wildlife. They will also enable us to improve and refine existing surveillance and control programs.

Antimicrobial resistance in *Escherichia coli* isolates from swine and wild small mammals in proximity to swine farms and in natural environments in Ontario.

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This study was conducted to evaluate the effect of habitat (farm or natural area) on the presence of antimicrobial resistance in generic *Escherichia coli* isolates obtained from wild small mammals (i.e. mice, voles, and shrews). Additionally, we compared the types and distribution of antimicrobial resistance in *E. coli* isolated from pigs living on the same farms from which wild small mammals were collected.

Wild small mammals were trapped between June and November, 2007. In total, 42 *E. coli* isolates were recovered from 22 wild small mammals trapped on farms, and 37 isolates were recovered from 20 wild small mammals trapped in natural areas. Fecal samples from swine were collected between 2005 and 2008, with additional sampling in 2007 to correspond with the wild mammal trapping. All *E. coli* isolates from wild small mammals and 25 isolates from pooled fecal samples collected from each of 5 swine farms were tested for susceptibility to 15 antimicrobials (Table).

	Antimicrobial[a]	Number (%) of resistant isolates from swine (n = 125)	Number (%) of resistant isolates from wild small mammals	
			Farms (n = 42)	Natural areas (n = 37)
I	Amoxicillin-clavulanic acid	5 (4)	0 (0)	0 (0)
	Ceftiofur	3 (2)	0 (0)	0 (0)
	Ceftriaxone	3 (2)	0 (0)	0 (0)
II	Ampicillin	28 (22)	1 (2)	3 (8)
	Cefoxitin	3 (2)	1 (2)	0 (0)
	Kanamycin	11 (9)	0 (0)	0 (0)
	Streptomycin	48 (38)	3 (7)	0 (0)
	Trimethoprim-sulfamethoxazole	8 (6)	1 (2)	0 (0)
III	Chloramphenicol	13 (10)	2 (5)	0 (0)
	Sulfisoxazole	62 (50)	5 (12)	0 (0)
	Tetracycline	104 (83)	10 (24)	2 (5)
IV				

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] No resistance to amikacin, ciprofloxacin, gentamicin, or nalidixic acid was detected in *E. coli* isolates from either wild small mammals or swine.

Small mammals caught on farms were 5 times as likely to carry tetracycline-resistant *E. coli* as were those living in natural areas. Resistance to tetracycline was the most commonly detected resistance in isolates recovered from swine (83% of isolates). Our findings suggest that wild small mammals living on farms are more likely to carry *E. coli* than are those from natural areas believed to be less impacted by humans and agricultural activities. We hypothesize that proximity to food-animal agriculture increases the likelihood of antimicrobial resistance in *E. coli* isolated from wild animals, possibly through exposure to resistant *E. coli* from livestock, to their resistance genes, or to antimicrobials through contact with animal feed.

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Box 6. Methicillin-resistant *Staphylococcus aureus* in retail meat: 2008-2009.

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Methicillin-resistant *Staphylococcus aureus* (MRSA) is a critically important human pathogen. Over the past 10 to 15 years, there has been a dramatic increase in community-associated MRSA infections internationally, and the role of animals and food has been questioned. In Europe, a particular strain of MRSA, ST398, has emerged in food animals in previously low MRSA-prevalence countries and is now accounting for a large and increasing percentage of human infections. Direct or indirect contact with food animals is a risk factor for MRSA infection and concerns have been expressed about the potential role of meat as a vehicle for MRSA transmission. Given these concerns, prospective surveillance of retail meat was performed.

Retail meat samples were purchased via CIPARS sampling and tested for MRSA contamination. The first study identified MRSA contamination in 31/402 (8%) samples of pork chops, ground pork, and pork shoulders from British Columbia, Saskatchewan, Ontario, and Québec. A strain most commonly associated with horses and horse personnel, CMRSA-5, accounted for 39% of all isolates, whereas 32% were the food-animal-associated strain ST398 and 29% were strain CMRSA-2, a common human epidemic clone. A study was then conducted to detect and quantify MRSA in beef and pork in British Columbia, Saskatchewan, and Ontario. Isolates of MRSA were recovered from 8/127 (6%) ground pork samples, 14/89 (16%) pork chops, and 11/198 (6%) ground beef samples. Fifty-nine percent of positive pork samples were only positive on enrichment culture, with detected levels in quantifiable samples ranging from 20 to 3,590 colony-forming units (CFU)/g. Similarly, 45% of beef samples were positive only on enrichment culture. Therefore, most samples presumably contained very low quantities of MRSA and even samples that were quantifiable tended to have low levels of contamination. Of the quantifiable samples, levels ranged from 20 to 240 CFU/g. All isolates were classified as CMRSA-2. The predominance of this human MRSA clone raises questions about the origin of contamination of meat, particularly considering that ST398, the strain most commonly associated with food animals, was not detected. Retail chicken was also evaluated, with MRSA present in only 1/250 (0.4%) of samples, on both direct and enrichment culture. Only 1 colony was present on direct culture, indicating very low-level (approximately 20 CFU/g) contamination.

Found relatively commonly in retail meat in Canada, MRSA has been reported in some other regions. Strains found in meat are of concern because of their role in human disease, although currently ST398 infections are rare in people in Canada. The relevance of MRSA contamination is unclear. While it is plausible that food could act as a vehicle for MRSA transmission, no objective evidence is yet available. The source of contamination is also unclear, particularly given the 6% prevalence in retail beef yet the inability to find MRSA in feedlot cattle in Canada, based on results of a feedlot study in Alberta where MRSA was not isolated from any of the almost 500 cattle. Other sources of contamination such as slaughterhouse and processing environments, as well as from people in slaughterhouses to retail stores, are also possible.

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Box 7. *Clostridium difficile* in retail meat.

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Clostridium difficile infection is an important cause of enteric disease in people. Once primarily a hospital-associated pathogen, it appears to be emerging as an important cause of community-associated disease. Further, the epidemiology of *C. difficile* infection (CDI) is changing, with increased morbidity, mortality, and relapse rates. Much of this has been attributed to the emergence of ribotype 027/NAP1. There is some indication that another strain, ribotype 078/toxinotype V, may be over-represented in community-associated CDI in people. Because these 2 strains have been the most common strains identified in food animals and preliminary studies of food, food has been hypothesized to be a source of infection.

After initial studies indicating the presence of *C. difficile* in retail meat in Canada, additional studies were undertaken to better estimate the prevalence, strain distribution, and regional distribution in the country. *Clostridium difficile* was isolated from 7/393 (2%) retail pork samples from British Columbia, Saskatchewan, Ontario, and Québec. The most common strain was ribotype 027. Whereas the infectious dose of *C. difficile* for humans is not known and is probably variable, the level of meat contamination may be an important factor. Accordingly, a study was conducted to detect and quantify *C. difficile* in retail pork and beef from British Columbia, Saskatchewan, Ontario, and Québec. *Clostridium difficile* was isolated from 14/115 (12%) ground beef and 14/115 (12%) ground pork samples. For ground beef, 10 of 14 positive samples were positive on enrichment culture, with samples that were quantifiable only having 120 to 240 spores/g. For ground pork, 10 of 14 samples were positive on enrichment culture only, and 20 to 60 spores/g were identified in quantifiable samples. Ribotype 078 predominated in both beef and pork, and ribotype 027 was also identified. *Clostridium difficile* was also isolated from 26/208 (13%) retail chicken meat samples from Ontario. All isolates from chicken were ribotype 078 and were only positive with enrichment culture, suggesting that *C. difficile* was present at very low (< 20 colony forming units/g) levels.

Clostridium difficile is present in a variety of retail meat products across Canada. In general, the levels are low. The relevance of this is unclear. Low-level exposure to *C. difficile* in meat, water, and vegetables and from environmental sources may be common, and meat may not be a serious concern. It is also possible that food is only a relevant source of infection for people already at high risk, such as those being treated with antimicrobials, people with concurrent disease, and immunosuppressed individuals. However, the presence in retail meat of *C. difficile* strains that are important in community-associated infections and the ability of *C. difficile* spores to survive cooking indicate that further study of the relevance of this is needed.

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Box 8. Characterization of antimicrobial resistance in *Escherichia coli*, enterococci, and *Salmonella* recovered from retail meat in Alberta.

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The objective of this study was to characterize antimicrobial resistance in *Escherichia coli*, *Enterococcus*, and *Salmonella* isolated from retail meat samples in Alberta. The sampling plan used by CIPARS was followed and involved continuous weekly sampling from retail stores in randomly selected census divisions, weighted by population. A total of 564 samples comprising chicken (n = 206), beef (134), pork (133), and turkey (91) meats were collected. Generic *E. coli*, enterococci, and *Salmonella* were isolated, and isolate identities were confirmed by means of standard culture, biochemical, and polymerase chain reaction methods.

Bacteria	Chicken (n = 206)		Beef (n = 134)		Pork (n = 133)		Turkey (n = 91)	
	Number of positive samples	Number of isolates	Number of positive samples	Number of isolates	Number of positive samples	Number of isolates	Number of positive samples	Number of isolates
Escherichia coli	197	394	110	220	40	79	78	156
Enterococci	206	412	132	264	118	221[a]	91	182
Salmonella	83	249	0	0	3	9	25	75

[a] Although 2 enterococcal isolates were recovered per positive sample during primary isolation, when attempts were made to re-culture enterococci from frozen stock for antimicrobial susceptibility testing, 15 pork-related isolates were non-viable, resulting in a total of 221 isolates rather than the expected isolate yield of 236.

A total of 849 *E. coli* isolates and 1,079 *Enterococcus* isolates comprising 2 isolates from each of the 4 meat types were analyzed for antimicrobial resistance. Three isolates of *Salmonella* were selected from each positive sample for a total of 333 isolates. Antimicrobial susceptibility to 15 antimicrobials for *E. coli* and *Salmonella* and 17 antimicrobials for enterococci was determined by use of an automated system. The results were interpreted according to the Clinical Laboratory Standard Institute guidelines.

Antimicrobial resistance was more common in *E. coli* isolates recovered from chicken and turkey samples than in isolates from beef and pork samples. Thirty-six percent and 23% of *E. coli* isolates from chicken were resistant to amoxicillin-clavulanic acid and ceftiofur, respectively. Both of these antimicrobials are classified as Category I agents (Very High Importance in Human Medicine). Resistance to more than 2 antimicrobials was also common among these chicken *E. coli* isolates.

Enterococcus faecalis was the most common (> 90%) enterococcal species identified, followed by *E. faecium* (4%). High percentages of enterococci isolated from chicken samples were resistant to erythromycin (47%), lincomycin (94%), and tylosin (27%). All of these antimicrobials belong to Category II of the Veterinary Drugs Directorate's ranking of antimicrobials (High Importance in Human Medicine). A comparatively small number of enterococci from beef, pork, and turkey meats were resistant to these antimicrobials. All enterococci were susceptible to vancomycin.

Salmonella was recovered from chicken, turkey, and pork samples; no *Salmonella* was recovered from beef samples. The most common *Salmonella* serotypes identified were Hadar (27% of isolates), Heidelberg (23%), and Kentucky (16%). In *Salmonella* isolated from chicken and turkey samples, resistance was common to the following antimicrobials: tetracycline (51% chicken; 45% turkey), streptomycin (31% chicken; 30% turkey), amoxicillin-clavulanic acid (22% chicken; 27% turkey), ampicillin (22% chicken; 27% turkey), ceftiofur (22% chicken; 27% turkey), and cefoxitin (22% chicken; 27% turkey). Intermediate susceptibility to ceftriaxone (19% chicken; 27% turkey) was also identified. The *Salmonella* antimicrobial susceptibility results presented here are preliminary because susceptibility results for 99 isolates were pending at the time of publication of this report.

In summary, these preliminary data suggest that resistant *E. coli*, enterococci, and *Salmonella* are more prevalent in retail chicken meat (40%) and turkey (27%) than in pork (2%) and beef (0%).

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Appendix A – Methods

Categorization of Antimicrobials Based on Importance in Human Medicine

Categories of antimicrobials used in this report were taken from the document Categorization of Antimicrobial Drugs Based on Importance in Human Medicine[1] by Health Canada's Veterinary Drugs Directorate (Table A.1).

Antimicrobials are considered to be of Very High Importance in Human Medicine (Category I) when they are essential for the treatment of serious bacterial infections and there is no or limited availability of alternative antimicrobials for effective treatment. Antimicrobials of High Importance in Human Medicine (Category II) consist of those that can be used to treat a variety of infections, including serious infections, and for which alternatives are generally available. Bacteria resistant to antimicrobials of this category are generally susceptible to Category I antimicrobials, which could be used as alternatives. Antimicrobials of Medium Importance in Human Medicine (Category III) are used in the treatment of bacterial infections for which alternatives are generally available. Infections caused by bacteria resistant to these antimicrobials can, in general, be treated with Category II or I antimicrobials. Antimicrobials of Low Importance in Human Medicine (Category IV) are currently not used in human medicine.

TABLE A.1. Categorization of antimicrobial drugs based on importance in human medicine.

Category of importance in human medicine		Antimicrobial class
I	Very High Importance	Carbapenems Cephalosporins – the 3rd and 4th generations Fluoroquinolones Glycopeptides Glycylcyclines Ketolides Lipopeptides Monobactams Nitroimidazoles (metronidazole) Oxazolidinones Penicillin-β-lactamase inhibitor combinations Polymyxins (colistin) Therapeutic agents for tuberculosis (e.g. ethambutol, isoniazid, pyrazinamide, and rifampin)
II	High Importance	Aminoglycosides (except topical agents) Cephalosporins – the first and second generations (including cephamycins) Fusidic acid Lincosamides Macrolides Penicillins Quinolones (except fluoroquinolones) Streptogramins Trimethoprim-sulfamethoxazole
III	Medium Importance	Aminocyclitols Aminoglycosides (topical agents) Bacitracins Fosfomycin Nitrofurans Phenicols Sulfonamides Tetracyclines Trimethoprim
IV	Low Importance	Flavophospholipols Ionophores

[1] Version April, 2009. Available at: www.hc-sc.gc.ca/dhp-mps/consultation/vet/consultations/amr_ram_hum-med-rev-eng.php. Accessed February 2010.

Sampling Design and Data Collection

Surveillance of Human Clinical Isolates

The objectives of the *Surveillance of Human Clinical Isolates* component of CIPARS are to provide a representative and methodologically unified approach to monitor temporal trends in the development of antimicrobial resistance in *Salmonella* isolated from humans.

Hospital-based or private clinical laboratories usually culture human *Salmonella* isolates in Canada. Although reporting is mandatory through laboratory notification of reportable diseases to the National Notifiable Disease Reporting System, forwarding of *Salmonella* cultures to provincial reference laboratories is voluntary and passive. A high proportion (84% in 2001)[1] of *Salmonella* isolates is forwarded to Provincial Public Health Laboratories (PPHLs), but this proportion may vary among laboratories. The Yukon, Northwest Territories, and Nunavut, which do not have a PPHL counterpart, also forward isolates to one of the PPHLs.

Prior to 2002, PPHLs forwarded a certain number of *Salmonella* isolates to the Enteric Diseases Program, National Microbiology Laboratory (NML), Public Health Agency of Canada (PHAC), Winnipeg, Manitoba for confirmation and subtype characterization. A letter of agreement by which provinces agreed to forward all or a subset of their *Salmonella* isolates to CIPARS was signed in 2002 by the PPHLs, the NML, the Laboratory for Foodborne Zoonoses (LFZ), and the Centre for Food-borne, Environmental and Zoonotic Infectious Diseases of the PHAC. This agreement officially launched the Surveillance of Human Clinical Isolates component of CIPAR*S.*

To ensure a statistically valid sampling plan, all human *Salmonella* isolates (outbreak-associated and non-outbreak-associated) received passively by PPHLs in Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador were forwarded to the NML. The PPHLs in more heavily populated provinces (British Columbia, Alberta, Ontario, and Québec) forwarded only the isolates received from the 1st to the 15th of each month. However, all human *S.* Newport and *S.* Typhi isolates were forwarded to the NML because of concerns of multidrug resistance and clinical importance, respectively.

The PPHLs were also asked to provide a defined set of data for each forwarded isolate, including serovar name, date collected, outbreak identification (if applicable), and patient age, sex, and province of residence. Provision of patient information on travel history, antimicrobial use, hospitalization status at the time of sample collection, and date of disease onset was optional. These optional data were not usually available to the NML in 2008. Although many outbreaks are identified by PPHLs prior to isolate submission, some outbreaks are identified after the isolates are forwarded to the NML. For 2008, there was no outbreak identification information available to accompany any isolates submitted to the NML.

Farm Surveillance

The objectives of the CIPARS *Farm Surveillance* component are to provide data on antimicrobial use (Antimicrobial Use, Appendix A) and resistance, monitor temporal trends in the development of antimicrobial resistance, investigate associations between antimicrobial use and resistance on grower-finisher pigs, and provide data for human-health risk assessments.

Farm Surveillance is the most recent component of CIPARS and complements existing abattoir and retail sample collection activities. This initiative focuses on a sentinel farm framework that provides data on antimicrobial use and fecal samples obtained from farms for bacterial isolation and antimicrobial susceptibility testing. It is administered and coordinated by the LFZ.

[1] Report of the 2001 Canadian Laboratory Study, National Studies on Acute Gastrointestinal Illness, Division of Enteric, Foodborne and Waterborne Diseases, 2002.

In 2006, the CIPARS *Farm Surveillance* component was implemented in swine herds across the 5 major pork-producing provinces in Canada (Alberta, Saskatchewan, Manitoba, Ontario, and Québec). The swine industry was selected as the pilot commodity for development of the farm surveillance infrastructure because the Canadian Quality Assurance (CQA®) program had been extensively implemented by the industry and because there has not been a recent outbreak of foreign animal disease in pigs.

The *Farm Surveillance* component concentrates on grower-finisher hogs. Pigs in this stage of production were chosen because of their proximity to the consumer.

Nationally, 23 veterinarians and 96 sentinel grower-finisher sites were enrolled. In each of the 5 participating provinces, the number of CIPARS sentinel sites was proportional to the national total of grower-finisher units, except in Alberta, where 10 additional sentinel herds were included. Alberta Agriculture and Rural Development (AARD) provided laboratory testing for all samples collected from the CIPARS sentinel herds in Alberta.

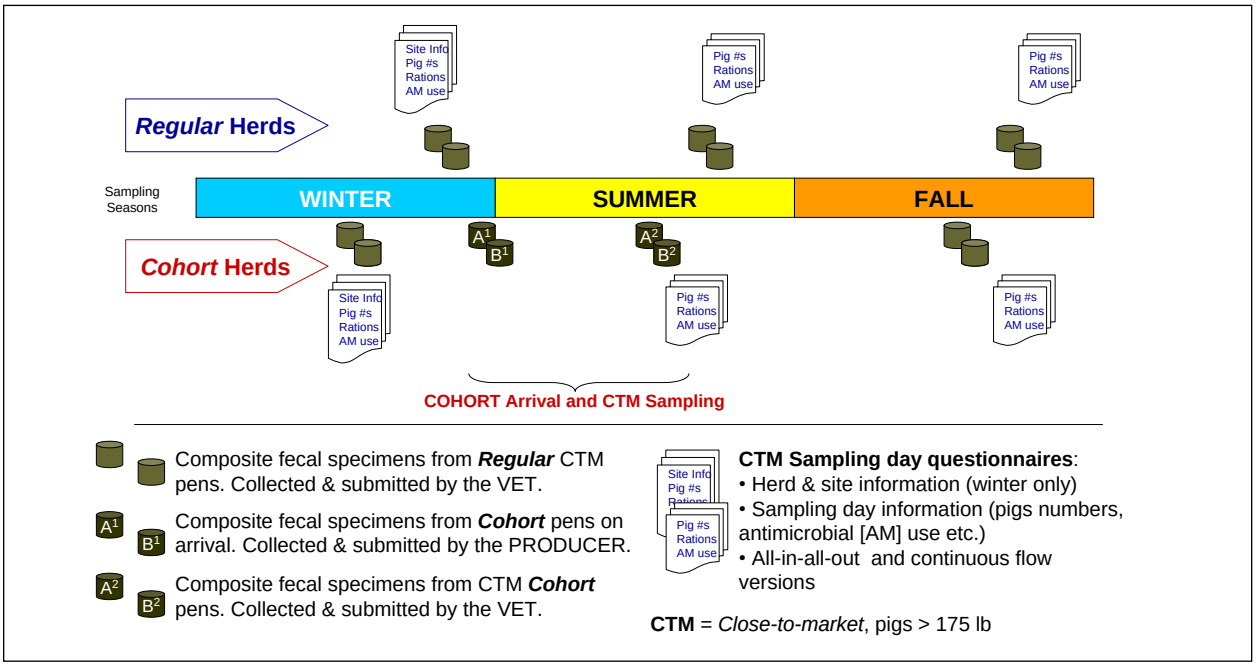
To preserve the anonymity of participating producers, herd veterinarians collected the samples and data and submitted depersonalized information to PHAC. In the case of corporate herds, 2 private supervisory veterinarians ensured confidentiality by holding the key to corporate herd codes. This step was taken because knowing a corporate veterinarian's name could have identified the corporation associated with the herd, thereby breaking anonymity.

Veterinarians were purposively selected from the list of veterinarians practicing swine medicine in each province. Each veterinarian selected a predetermined number of sentinel farm sites by use of specific inclusion and exclusion criteria. To be included, herds were required to be CQA® validated, produce more than 2,000 market pigs per year, and be representative of the characteristics (i.e. similar production volumes and types of production systems) and geographic distribution of herds in the contractor's swine practice. Herds were excluded when they were regarded as organic with respect to animal husbandry, were fed edible residual material, or were raised on pasture. These criteria helped ensure that the herds enrolled were representative of most grower-finisher swine herds in Canada.

Pooled fecal samples were collected 3 times per year from pens of pigs that were close to market (CTM) weight (i.e. more than 175 lb; Figure A.1). In a subset of herds, specific cohorts of pigs were sampled twice: within 6 hours after pigs entered the grow-finisher unit and again when the same pigs reached CTM weight.

Antimicrobial resistance data for bacterial isolates recovered from pooled fecal samples of CTM pigs are presented in this report. Data are not presented for pooled fecal samples collected when pigs arrived in grower-finisher units; however, these data are available upon request. Overall prevalence estimates, which were calculated from data for arrival and CTM market samples, are also not presented here.

FIGURE A.1. Example of sampling visits in regular and cohort swine herds over a calendar year.



Abattoir Surveillance

The objectives of the CIPARS *Abattoir Surveillance* component are to provide nationally representative, annual antimicrobial resistance data for bacteria isolated from animals entering the food chain, and to monitor temporal trends in the development of antimicrobial resistance in these bacteria. Initially, this component targeted generic *Escherichia coli* and *Salmonella* from beef cattle, pigs, and broiler chickens. In 2003, the component was refined to discontinue *Salmonella* isolation from beef cattle because of the low prevalence of *Salmonella* in that population. An additional change was the addition of *Campylobacter* surveillance in beef cattle in late 2005.

In the *Abattoir Surveillance* component, the unit of concern (i.e. the subject of interest) was the bacterial isolate. The bacteria of interest were sampled from the caecal contents (not carcasses) of slaughtered food animals to avoid misinterpretation related to cross-contamination and to better reflect antimicrobial resistance in bacteria that originated on the farm.

The sampling method used was designed with the expectation that, across Canada, 150 isolates of each targeted bacterial species would be recovered from each of the 3 animal species over a 12-month period to avoid any potential seasonal bias in bacterial prevalence and antimicrobial susceptibility. The exception to this expectation was *Campylobacter* in beef cattle, for which it was estimated that 100 isolates would be recovered over the same period. These numbers represented a balance between acceptable statistical precision and affordability (Ravel, 2001). The actual number of samples collected was determined for each food animal species on the basis of the expected caecal prevalence of the bacteria in that animal species. For example, if the expected bacterial prevalence was 10%, then 1,500 samples would need to be collected and submitted for bacterial isolation.

The sampling design was based on a 2-stage sampling plan, with each commodity handled separately. The first stage consisted of random selection of federally inspected slaughterhouses. The probability of an abattoir being selected was proportional to its annual slaughter volume. Federally inspected abattoirs slaughter over 90% of all food animals in Canada.[1] The second stage involved systematic selection of animals on the slaughter line. The annual number of caecal samples collected at each abattoir was proportional to its slaughter volume.

To minimize shipping costs and allow each abattoir to maintain efficiency, the annual total number of samples to be collected in each abattoir was divided by 5, resulting in the number of collection periods. For each collection period, 5 caecal samples were collected within 5 days, at the convenience of the slaughterhouse staff, provided the 5 animals and associated samples originated from different groups. Sampling from different groups of animals was important to maximize diversity and avoid bias attributable to overrepresentation of particular producers. Collection periods were uniformly distributed throughout the year, leading to an abattoir-specific schedule for collection of caecal contents. The uniform distribution of the collection periods helped to avoid any bias that may have resulted from seasonal variation in bacterial prevalence and antimicrobial susceptibility test results.

Forty-two federally inspected slaughter plants (24 poultry plants, 12 swine plants, and 6 beef cattle plants) from across Canada participated in the 2008 CIPARS *Abattoir Surveillance* component. For pigs and chickens, numbers of samples collected were based on the aforementioned expectation of 150 *Salmonella* and 150 *E. coli* isolates and the expected prevalence of *Salmonella* and *E. coli* in each animal species. For beef cattle, the number of samples collected was based the expectation of 100 *Campylobacter* and 150 *E. coli* isolates and the expected prevalence of *Campylobacter* and *E. coli* in the cattle. Samples were obtained according to a predetermined protocol, with modifications to accommodate various production-line configurations in the different plants. Protocols were designed to avoid conflict with carcass inspection methods, plant-specific Food Safety Enhancement Programs, and Health and Safety requirements. They were also designed to avoid situations of potential cross-contamination. All samples were collected by industry personnel under the oversight of the Veterinarian-in-Charge of the Canadian Food Inspection Agency (CFIA).

[1] Agriculture and Agri-Food Canada. Red meat market information. Available at: www.agr.gc.ca/redmeat-vianderouge/index_eng.htm. Accessed November 2010.

Retail Meat Surveillance

The objectives of CIPARS *Retail Meat Surveillance* are to provide data on antimicrobial resistance and to monitor temporal variations in selected bacteria found in raw meat at the provincial/region level. Retail surveillance also provides a measure of human exposure to antimicrobial-resistant bacteria via undercooked meat consumption. Retail food represents a logical sampling point for surveillance of antimicrobial resistance because it is the endpoint of food animal production. The focus of the surveillance framework can be modified (e.g. food commodities, bacteria, or regions) as necessary and functions as a research platform for investigation of specific questions regarding antimicrobial resistance in the agri-food sector.

As with *Abattoir Surveillance*, the unit of concern in *Retail Meat Surveillance* was the bacterial isolate cultured from one of the commodities of interest. In this situation, the commodities were raw meat products commonly consumed by Canadians, which originated from the 3 animal species sampled in the *Abattoir Surveillance* component. These raw meat products consisted of poultry (chicken legs or wings [skin on]),[1] pork (chops), and beef (ground beef).

For ground beef, only samples of lean ground beef were collected in the first year of surveillance (2003); however, in 2004, the scope was widened to include systematic selection of extra-lean, lean, medium, and regular ground beef. This change was made to ensure representation of the heterogeneity of ground beef with respect to its origins (e.g. domestic vs. imported beef or raised beef cattle vs. culled dairy cattle). The meat cuts "legs or wings with skin on," "chops," and "ground beef" were chosen on the basis of suspected high prevalences of the targeted bacterial species within and the low purchase prices of these commodities (Ravel, 2002).

Bacteria of interest in chicken were *Campylobacter*, *Salmonella*, *Enterococcus*, and generic *E. coli*. In pork both *Salmonella* and *E. coli* were cultured, but only isolates of *E. coli* underwent antimicrobial susceptibility testing. *Salmonella* was isolated from pork mainly to provide recovery estimates from this commodity for other PHAC programs. Because the prevalence of *Salmonella* in pork is low, antimicrobial susceptibility results are not presented separately for each year but, rather, have been combined. Recovery of *Campylobacter* from pork was not attempted because of the low prevalence observed in the initial stages of *Retail Meat Surveillance*. In beef, only *E. coli* was cultured and then tested for antimicrobial susceptibility given the low prevalence of *Campylobacter* and *Salmonella* in these commodities at the retail level, as determined during the early phase of the program. Lastly, the presence of *Enterococcus* in beef and pork was not determined because of resource and budgetary constraints.

The sampling protocol was designed to evaluate antimicrobial resistance in certain bacterial species that contaminate retail meat and to which Canadian consumers may subsequently be exposed. It primarily involved continuous weekly submission of samples of retail meat from randomly selected geographic areas (i.e. census divisions defined by Statistics Canada), weighted by population, in each participating province. In 2008, retail meat samples were collected in British Columbia, Saskatchewan, Ontario, and Québec, and the Maritimes region (Nova Scotia, New Brunswick, and Prince Edward Island). Data from Statistics Canada were used to define strata. This was done by using cumulative population quartiles (or thirdtiles) from a list of census divisions in a province, sorted by population in ascending order. Between 15 and 18 census divisions per province were then chosen by means of stratified random selection and weighted by population within each stratum. The number of sampling days allocated to each stratum was also weighted by population and is summarized as follows:

Ontario and Québec

- Stratum One - 10 divisions selected, with 2 sampling days per division per year
- Stratum Two - 4 divisions selected, with 5 sampling days per division per year
- Stratum Three - 2 divisions selected, with 10 sampling days per division per year
- Stratum Four - 1 division selected, with 20 sampling days per year

[1] When legs with skin on were not available, wings with skin on or other cuts of chicken were purchased instead.

Saskatchewan

- Stratum One - 9 divisions selected, with 2 sampling days per division per year
- Stratum Two - 5 divisions selected, with 3 sampling days per division per year
- Stratum Three - 2 divisions selected, with 5 sampling days per division per year
- Stratum Four - 1 division selected, with 7 sampling days per year

British Columbia

- Stratum One - 10 divisions selected, with 1 sampling day per division per year
- Stratum Two - 4 divisions selected, with 3 sampling days per division per year
- Stratum Three - 1 division selected, with 20 sampling days per year.

Maritime Provinces

For the 3 Maritimes provinces, results are aggregated and presented at the Maritimes region level; however, sampling activities for this region were proportional to the population within each province as indicated below. Furthermore, as with the other provinces sampled in the retail component, sampling within each province was proportional to the census division subpopulations and is summarized as follows:

Nova Scotia

- Stratum One - 5 divisions selected, with 1 sampling day per division per year (on average)
- Stratum Two - 4 divisions selected, with 2 sampling days per division per year
- Stratum Three - 1 division selected, with 10 sampling days per division per year

New Brunswick

- Stratum One - 5 divisions selected, with 1 sampling day per division per year (on average)
- Stratum Two - 4 divisions selected, with 2 sampling days per division per year
- Stratum Three - 2 divisions selected, with 4 sampling days per division per year (on average)

Prince Edward Island

- Stratum One - 1 division selected, with 1 sampling day per division per year
- Stratum Two - 1 division selected, with 2 sampling days per division per year.

Field workers in Ontario and Québec conducted sampling on a weekly basis, and those in British Columbia, Saskatchewan, and Maritimes region conducted sampling every other week. Sampling was less frequent in British Columbia, Saskatchewan, and the Maritimes region because of funding constraints, limited laboratory capacity, and a desire to avoid over-sampling at particular stores. Samples were collected on Mondays or Tuesdays for submission to the LFZ, Saint-Hyacinthe, Québec (LFZ-Saint-Hyacinthe) by Wednesday. Samples submitted from outside Québec (with the exception of samples from the Maritimes region) were sent to the same laboratory via 24-hour courier. Samples from the whole Maritimes region were collected on Mondays or Tuesdays and submitted to a laboratory in Prince Edward Island within 24 hours.

In each province, 2 census divisions were sampled each sampling week. In each census division, 4 stores were selected prior to the sampling day, based on store type. Generally, 3 chain stores and 1 independent market or butcher shop were selected. An exception to this protocol was made in densely populated urban census divisions (e.g. Toronto or Montréal), where 2 chain stores and 2 independent markets or butcher shops were sampled to reflect the presumed shopping behaviour of that subpopulation. From each store type, 1 sample of each commodity of interest was collected, for a total of 11 meat samples (4 chicken, 4 pork, and 3 beef samples) per division per sampling day.[1] When possible, specific stores were sampled only once per sampling year.

[1] At 1 store in each division, the beef sample was not collected to minimize over-sampling of this commodity.

Prevalence estimates were used to determine the numbers of samples to be collected, which were based on an expected yield of 100 isolates per commodity per province per year, plus 20% to account for lost or damaged samples. Because sampling was less frequent in British Columbia, Saskatchewan, and the Maritimes region than in Ontario and Québec, the target of 100 isolates per year may not have always be met in those provinces.

- In 2008, personal digital assistants (PDAs) were used to capture the following store and sample data:
- Type of store
- Number of cash registers (surrogate measure of store volume)
- "Sell-by" or packaging date
- "May contain previously frozen meat" label - yes or no
- Final processing in store - yes, no, or unknown
- Air chilled - yes, no, or unknown (applied to chicken samples only)
- Organic - yes, no, or unknown
- Antimicrobial free - yes, no, or unknown
- Price per kilogram.

Individual samples were packaged in sealed zipper-type bags and placed in 16-L thermal coolers for transport. The ambient environmental temperature was used to determine the number of ice packs placed in each cooler (i.e. 1 ice pack for temperatures below 20ºC and 2 ice packs for temperatures 20ºC or higher). In 1 or 2 coolers per sampling day, instruments for recording temperature data (Ertco Data Logger™, West Patterson, NJ, USA) were used to monitor temperatures to which samples were exposed.

Surveillance of Animal Clinical Isolates

The objective of *Surveillance of Animal Clinical Isolates* is to detect new and/or emerging antimicrobial resistance patterns or new serovar/antimicrobial resistance pattern combinations in *Salmonella*. This component of CIPARS is primarily based on veterinary diagnostic submissions collected by veterinarians and/or producers. Consequently, methods of sample collection and submission varied among laboratories. *Salmonella* isolates were sent by provincial and private animal health laboratories from across the country to the *Salmonella* Typing Laboratory (STL) at the LFZ, Guelph, Ontario (LFZ-Guelph). *Salmonella* isolates from the Direction des laboratoires d'expertises du Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec were sent to the Laboratoire d'épidémiosurveillance animale du Québec, Saint-Hyacinthe, Québec. However, unlike the *Surveillance of Human Clinical Isolates* component, not all isolates received by provincial animal health laboratories were necessarily forwarded to the LFZ, with the exception of the provinces of British Columbia, Ontario, and Québec. Therefore, coverage may have varied considerably among provinces.

Feed and Feed Ingredients

Data from the *Feed and Feed Ingredients* component of CIPARS were obtained from various sources, including monitoring programs of the CFIA and a few isolates from provincial authorities. Information on specimen collection methods was only available for the CFIA monitoring programs.

The CFIA collects samples of animal feed under 2 different programs: Program 15A (Monitoring Inspection – *Salmonella*) and Program 15E (Directed Inspection – *Salmonella*). Under Program 15A, feeds produced at feed mills, rendering facilities, ingredient manufacturers, and on-farm facilities are sampled and tested for *Salmonella*. Although this program makes use of a random sampling process, extra attention is paid to feeds that are more likely to have a higher degree of *Salmonella* contamination, such as those that contain rendered animal products, oilseed meals, fishmeals, grains, and mashes. Program 15E targets feeds or ingredients from establishments that (i) produce rendered animal products, other feeds containing ingredients in which *Salmonella* could be a concern (e.g. oilseed meal or fishmeal), or a significant volume of poultry feed; (ii) are known to have repeated problems with *Salmonella* contamination; or (iii) have identified a *Salmonella* serovar that is highly pathogenic (e.g. Typhimurium, Enteritidis, or Newport). Program 15E is a targeted program; samples are not randomly selected.

Bacterial Isolation

All samples were cultured by use of standard protocols as described below. All primary isolation of human *Salmonella* isolates was conducted by hospital-based or private clinical laboratories from across the provinces. Most primary isolation of *Escherichia coli, Salmonella*, *Enterococcus*, and *Campylobacter* from agri-food samples was conducted at the LFZ-Saint-Hyacinthe. Part of the primary isolation for *Farm Surveillance* was conducted at the Agri-Food Laboratory, AARD. Samples from the CIPARS *Animal Clinical Isolates* component were cultured by various participating laboratories. Most primary bacterial isolation from *Feed and Feed Ingredients* sample was conducted by the CFIA – Laboratory Services Division (Calgary or Ottawa).

Salmonella

***Surveillance of Human Clinical Isolates*:** Hospital-based and private clinical laboratories isolated and identified *Salmonella* from human samples according to approved methods (Kauffman, 1966; Ewing, 1986; Le Minor, 2001; Murray et al., 2005).

***Farm Surveillance* and *Abattoir Surveillance*:** The method used to isolate *Salmonella* was a modification of the MFLP-75 method of the Compendium of Analytical Methods, Health Protection Branch, Methods of Microbiological Analysis of Food, Government of Canada. This method allowed isolation of motile and viable *Salmonella* from fecal samples from pigs and caecal contents from broiler chickens and pigs. It was based on the ability of *Salmonella* to multiply and be motile in modified semi-solid Rappaport Vassiliadis (MSRV) medium at 42°C. A 10-g portion of each pig sample was mixed with 90 mL of buffered peptone water (BPW), which served as a non-selective pre-enrichment broth. For chickens, caecal contents were weighed and BPW was added at a ratio of 1:10. The pig and chicken samples were incubated at 35 ± 1°C for 24 hours. Afterward, an MSRV plate was inoculated with 0.1 mL of the pre-enrichment broth and incubated at 42 ± 1°C for 24 to 72 hours. Suspect colonies were screened for purity and used to inoculate triple-sugar-iron and urea agar slants. Presumptive *Salmonella* isolates were then assessed with the indole test, and their identities were verified by means of slide agglutination with Poly A-I and Vi *Salmonella* antiserum.

***Retail Meat Surveillance*:** One chicken leg[1] was added to 225 mL of BPW. One hundred and fifty millilitres of the peptone rinse was kept for isolation of *Campylobacter*, *E. coli*, and *Enterococcus*. Chicken samples were left in the remaining 75-mL BPW rinse and were incubated at 35 ± 1°C for 24 hours. Afterward, an MSRV plate was streaked with 0.1 mL of the incubated rinse, and the plate was incubated at 42 ± 1°C for 24 to 72 hours. Suspect colonies were screened for purity and used to inoculate triple-sugar-iron and urea agar slants. Presumptive *Salmonella* isolates were assessed with the indole test, and their identities were verified by means of slide agglutination with Poly A-I and Vi *Salmonella* antiserum.

***Surveillance of Animal Clinical Isolates*:** *Salmonella* was isolated according to standard procedures, which varied among laboratories. Most methods for detecting *Salmonella* in animal clinical isolates were similar in principle and involved pre-enrichment, selective enrichment, differential and selective plating, isolation, and biochemical and serological confirmation of the selected isolates.

***Feed and Feed Ingredients*:** Under both CFIA programs (15A and 15E), all samples were collected aseptically and submitted for bacterial culture and isolation. For *Salmonella* isolation, MSRV medium was used.

Escherichia coli

***Farm Surveillance*:** One drop of the BPW mixture prepared for *Salmonella* isolation was streaked onto MacConkey agar and incubated at 35 ± 1°C for 18 to 24 hours. Suspect lactose-fermenting colonies were screened for purity and transferred onto Luria-Bertani agar. Presumptive *E. coli* colonies were assessed with Simmons citrate and indole tests. Isolates with negative indole results were identified with a test kit for identification of enteric bacteria (API®20E system, bioMérieux Clinical Diagnostics, Marcy l'Étoile, France).

[1] When legs with skin on were not available, wings with skin on or other cuts were purchased instead.

***Abattoir Surveillance*:** Generic *E. coli* was isolated from the caecal contents of broiler chickens, pigs, and beef cattle. Ten grams of each caecal sample was mixed with 90 mL of BPW. One drop of this mixture was streaked onto MacConkey agar and incubated at 35°C for 18 to 24 hours. Suspect lactose-fermenting colonies were screened for purity and transferred onto Luria-Bertani agar. Presumptive *E. coli* colonies were assessed with Simmons citrate and indole tests. Isolates with negative indole results were identified with a test kit for identification of enteric bacteria (API® 20E system).

***Retail Meat Surveillance*:** One chicken leg,1 1 pork chop, or 25 g of ground beef was added to 225 mL of BPW. Fifty millilitres of the peptone rinse was mixed with 50 mL of a double-strength broth for selective identification of coliform bacteria and *E. coli* (EC broth) and incubated at 45 ± 1°C for 24 hours. One loopful of the incubated mixture was streaked onto eosin methylene blue agar and incubated at 35 ± 1°C for 24 hours. Suspect colonies were screened for purity and transferred onto trypticase soy agar with 5% sheep blood. Presumptive *E. coli* colonies were assessed with Simmons citrate and indole tests. Isolates with negative indole results were identified with a bacterial identification test kit (API® 20E system).

Campylobacter

***Abattoir Surveillance*:** For isolation of *Campylobacter* from beef cattle caecal samples, 1 mL of the BPW mixture prepared for isolation of *E. coli was used. This volume was mixed with 9 mL of Hunt's enrichment broth (HEB) and incubated in a microaerophilic atmosphere at 35* ± 1°C for 4 hours. After this first incubation, 36 µL of sterile cefoperazone was added to the HEB. Tubes were then incubated in microaerophilic conditions at 42 ± 1°C for 20 to 24 hours. A loop of the incubated HEB was then used to inoculate a modified cefoperazone charcoal deoxylate agar (mCCDA) plate. Plates were incubated at 42 ± 1°C in microaerophilic conditions for 72 hours. Suspect colonies were streaked onto another mCCDA plate to obtain pure colonies and on Mueller Hinton agar supplemented with 5% sheep blood. Plates were incubated in a microaerophilic atmosphere at 42 ± 1°C for 48 to 72 hours. Presumptive *Campylobacter* colonies were identified by genus and species (*C. coli*, *C. jejuni*, or other *Campylobacter* spp.) via the following tests: Gram stain, oxidase, catalase, growth at 25 ± 1°C, cephalothin resistance, and hippurate and indoxyl acetate hydrolysis.

***Retail Meat Surveillance*:** One chicken leg[1] or 2 wings were mixed with 225 mL of BPW. Fifty millilitres of the peptone rinse was mixed with 50 mL of double-strength Bolton broth and incubated in a microaerophilic atmosphere at 42 ± 1°C for 48 hours. The incubated broth was then streaked onto an mCCDA plate and incubated in a microaerophilic atmosphere at 42 ± 1°C for 24 hours. Suspect colonies were streaked onto another mCCDA plate and a Mueller Hinton plate. Plates were incubated in a microaerophilic atmosphere at 42 ± 1°C for 48 to 72 hours. Presumptive *Campylobacter* colonies were identified by genus and species (*C. coli*, *C. jejuni*, or other *Campylobacter* spp.) via the following tests: Gram stain, oxidase, catalase, growth at 25 ± 1°C, cephalothin resistance, and hippurate and indoxyl acetate hydrolysis.

Enterococcus

***Farm Surveillance*:** One drop of the BPW mixture prepared for *Salmonella* isolation was streaked onto enterococcal isolation agar (Enterococcosel™ agar, BD, Mississauga, ON) and incubated at 35 ± 1°C for 24 hours. Suspect colonies were screened for purity on Columbia agar with 5% sheep blood. Presumptive *Enterococcus* colonies were transferred onto Slaneth and Bartley agar and used to inoculate 3 tubes of phenol-red base broth containing 0.25% L-arabinose, 1% mannitol, or 1% a-methyl-D-glucoside. The plate and tubes were incubated at 35°C ± 1°C for 24 hours.

***Retail Meat Surveillance*:** One chicken leg1 or 2 wings were added to 225 mL of BPW. Fifty millilitres of the peptone rinse was mixed with 50 mL of double-strength selective broth (Enterococcosel™ broth, BD) and incubated at 35 ± 1°C for 24 hours. One loopful of incubated broth was then streaked onto selective agar (Enterococcosel™ agar) and incubated at 35 ± 1°C for 24 hours. Suspect colonies were screened for purity on Columbia agar with 5% sheep blood. Presumptive *Enterococcus* colonies were transferred onto Slaneth and Bartley agar and used to inoculate 3 tubes of phenol-red base broth containing 0.25% L-arabinose, 1% mannitol, or 1% a-methyl-D-glucoside. The plate and tubes were incubated at 35 ± 1°C for 24 hours.

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[1] When legs with skin on were not available, wings with skin on or other cuts of chicken were purchased instead.

Serotyping and Phage Typing of *Salmonella*

***Surveillance of Human Clinical Isolates*:** In general, clinical laboratories forwarded their *Salmonella* isolates to their PPHL for identification and serotyping. The PPHL further forwarded *Salmonella* isolates to NML according to the predefined testing scheme. Isolate identities were confirmed by the NML when isolates received did not have a serovar name (Le Minor and Popoff, 2001) or when inconclusive results arose during phage typing. The O or somatic antigens of the *Salmonella* isolates were serotyped by use of a slide agglutination method (Ewing, 1986). At the NML, *Salmonella* H or flagellar antigens were detected via slide and confirmatory tube agglutination methods. *Salmonella* isolates were maintained at room temperature (25° to 35°C) until typed.

All *Salmonella* Heidelberg, *S.* Typhimurium, *S.* Enteritidis, *S.* Hadar, *S.* Newport, *S.* Typhi, *S.* Paratyphi B, *S.* Paratyphi B var. L(+) tartrate+, *S.* Infantis, *S.* Thompson, *S.* Oranienburg, *S.* Panama, *S.* I 4,[5],12:b:-, and *S.* I 4,[5],12:i:- isolates were phage following the standard technique described by Anderson and Williams (1956) was followed. Isolates were streaked onto nutrient agar plates and incubated at 37°C for 18 hours. One smooth colony was selected and used to inoculate 4.5 mL of phage broth (Difco™ phage broth, Difco Laboratories, Baltimore, MD; pH, 6.8), which was then incubated for 1.5 to 2 hours in a shaking water bath at 37°C to attain bacterial growth with a turbidity equivalent to 0.5 McFarland standard. Phage agar plates (Difco™ phage agar, Difco Laboratories) were flooded with approximately 2 mL of culture medium, and the excess liquid was removed with a Pasteur pipette. Flooded plates were allowed to dry for 15 minutes at room temperature. Afterward, approximately 20 mL of each serovar-specific typing phage was used to inoculate the bacterial lawn by means of a multiple inoculating syringe method (Farmer et al., 1975). The plates were incubated at 37°C overnight, and lytic patterns were subsequently interpreted (Anderson and Williams, 1956).

Salmonella Enteritidis isolates were phage typed with typing phages obtained from the International Centre for Enteric Phage Typing (ICEPT), Central Public Health Laboratories, Colindale, UK (Ward et al., 1987). The phage typing scheme and phages for *Salmonella* Typhimurium developed by Callow (1959) and further extended by Anderson (1964) and Anderson et al. (1977) were obtained from the ICEPT. The *Salmonella* Heidelberg phage typing scheme and phages were supplied by the NML (Demczuk et al., 2003). Isolates that reacted with the phages but did not conform to any recognized phage type were designated as atypical. Strains that did not react with any of the typing phages were designated as untypable.

The Identification and Serotyping and the Phage Typing units at the NML have attained International Standards Organization (ISO) 17025 accreditation by the Standards Council of Canada. The Identification and Serotyping, Phage Typing, and Antimicrobial Resistance units at the NML participate in the annual Global *Salmonella* Surveillance (GSS), External Quality Assurance System of the World Health Organization, the Enter-net (a European network for the surveillance of human gastrointestinal infections) proficiency program for *Salmonella*, and a strain exchange with the LFZ (*Salmonella* and *Escherichia coli*). The NML has been a strategic planning member of the GSS program since 2002.

Surveillance of Agri-Food, Animal Clinical, and Feed Isolates: Animal clinical *Salmonella* isolates from Québec were serotyped by the Laboratoire d'épidémiosurveillance animale du Québec, Saint-Hyacinthe, Québec and were sent to the STL[1] for phage typing. All *Salmonella* isolates from other provinces were submitted to the STL for serotyping and phage typing. The serotyping method detects O or somatic antigens of the *Salmonella* isolates via slide agglutination (Ewing, 1986). The H or flagellar antigens were identified with a microtitre plate well precipitation method (Shipp and Rowe, 1980). The Antigenic Formulae of the *Salmonella* serovars by Grimont and Weill (2007) were used to identify and name the serovars. For phage typing, the standard technique by Anderson and Williams (1956) and described above was followed. The sources of the typing phages for *Salmonella* Enteritidis, Typhimurium and Heidelberg were the same as described above for *Surveillance of Human Clinical Isolates.*

Since 1995, the STL has participated in annual inter-laboratory exchange serotyping panels with up to 3 other laboratories. The STL began external proficiency testing for phage typing in 2003. Every year, the STL participates successfully in phage typing proficiency panels provided by the NML, which originate from the Central Public Health Laboratory, Colindale, England.

[1] Office Internationale des Épizooties, OIÉ; All World Organisation for Animal Health, Reference Laboratory for Salmonellosis, Guelph, Ontario.

Antimicrobial Susceptibility Testing

All *Salmonella* isolates of human origin were tested for antimicrobial susceptibility at the NML, and all isolates of agri-food or feed origin were tested for antimicrobial susceptibility at the LFZ-Guelph. The majority of *Enterococcus*, *Campylobacter*, and *Escherichia coli* isolates from all agri-food components were tested by the LFZ-Saint-Hyacinthe. *Escherichia coli* isolates from *Retail Meat Surveillance* in Prince Edward Island were processed at the Atlantic Veterinary College, University of Prince Edward Island. In most instances, only 1 isolate per positive sample was tested for antimicrobial susceptibility. For Farm Surveillance, antimicrobial susceptibility testing was performed on 3 *E. coli* isolates, 3 *Enterococcus* isolates, and 1 *Salmonella* isolate per sample. A portion of the *Enterococcus* and *E. coli* isolates from *Farm Surveillance* in Alberta and Saskatchewan were processed by the Agri-Food Laboratory Branch, AARD. The LFZ-Guelph, LFZ-Saint-Hyacinthe, AARD, and Atlantic Veterinary College participate in external proficiency antimicrobial susceptibility testing for *Salmonella*, *E. coli*, and *Enterococcus*. Like the STL, the LFZ-Guelph laboratory for antimicrobial sensitivity testing is ISO/IEC 17025-accredited.

Salmonella, *Escherichia coli*, and *Enterococcus*

All *Salmonella* and *E. coli* isolates were tested for antimicrobial susceptibility with a panel of 15 antimicrobials (Table A.2) and for *Enterococcus* with a panel of 17 antimicrobials (Table A.3). The minimal inhibitory concentration (MIC) values for *Salmonella*, *E. coli*, and *Enterococcus* were determined by means of the broth microdilution method (Clinical and Laboratory Standards Institute [CLSI] M7-A7). This method was performed with an automated system (Sensititre™ Automated Microbiology System, Trek™ Diagnostic Systems Ltd, West Sussex, England). This system involves a commercially available broth dilution technique that makes use of dehydrated antimicrobials in the wells of microtitre plates. The CMV1AGNF susceptibility plates (Sensititre™, Trek™ Diagnostic Systems) of the National Antimicrobial Resistance Monitoring System were used for *E. coli* and *Salmonella* isolates, whereas CMV2AGPF plates were used for *Enterococcus* isolates.

Isolates were streaked onto a plate of Mueller Hinton agar (or Columbia blood agar or Mueller Hinton blood agar) and incubated in an inverted position at 36 ± 1°C for 18 to 24 hours to obtain isolated colonies. One colony was chosen from the plate and re-streaked onto agar plates for growth. The agar plates were subsequently incubated at 36 ± 1°C for 18 to 24 hours. A 0.5-McFarland suspension was prepared by transferring bacterial growth from the agar plates into 5.0 mL of sterile, demineralized water and suspending the organisms in the liquid by use of a vortex mixer. Ten microlitres of the water-bacteria suspension was transferred to a tube containing 10 mL of Mueller Hinton broth (MHB) and mixed with a vortex device. The MHB suspension was dispensed into plates at 50 mL per well. The plates were sealed with adhesive plastic sheets and incubated for 18 hours at 36 ± 1°C. Detection of possible vancomycin-resistant enterococci required 6 more hours of incubation for a total of 24 hours.

After incubation, the CMV1AGNF plates were read and interpreted with an automated reading and incubation system (ARIS®, Trek™ Diagnostic Systems Ltd), whereas the CMV2AGPF plates were read with the manual reader (Sensititre Sensitouch™, Trek™ Diagnostic Systems). In accordance with standards set by the CLSI (CLSI M100-S18), *Staphylococcus aureus* ATCC 29213, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, and *Enterococcus faecalis* ATCC 29212 were used for quality assurance purposes to ensure validity and integrity of the MIC values of the CMV1AGNF susceptibility panels. *Staphylococcus aureus* ATCC 29213, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212, and *Enterococcus faecalis* ATCC 51299 were used as quality control organisms for *Enterococcus* antimicrobial susceptibility testing.

Campylobacter

All *Campylobacter* isolates were tested for antimicrobial susceptibility with a panel of 9 antimicrobials (Table A.4). The MIC values for *Campylobacter* isolates were determined by means of the broth microdilution method (CLSI M7-A7). Antimicrobial susceptibility testing was performed with CAMPY susceptibility panels (Sensititre™) from the National Antimicrobial Monitoring System. The colonies were streaked onto Mueller Hinton agar plates with 5% sheep blood and incubated in a microaerophilic atmosphere at 42 ± 1°C for 24 hours. A 0.5-McFarland suspension of bacterial growth was prepared by transferring selected bacterial colonies into a tube containing 5 mL of MHB and mixing the tube contents with a vortex device for at least 10 seconds. Afterward, 10 mL of the MHB mixture was transferred into a tube containing 11 mL of MHB with laked horse blood and mixed for 10 seconds. The MHB mixture was dispensed into plates at 100 mL per well. The plates were sealed with adhesive plastic sheets and incubated in a microaerophilic atmosphere at 42 ± 1°C for 24 hours. *Campylobacter jejuni* ATCC 33560 was used as quality control organism. The MIC values obtained were compared with those of CLSI standards (CLSI M45-A).

TABLE A.2. Breakpoints in antimicrobial susceptibility of *Salmonella* and *Escherichia coli* isolates; CMV1AGNF plate, 2008.

	Antimicrobial	Range tested (μg/mL)	Breakpoints[a] (μg/mL)		
			S	I	R
I	Amoxicillin-clavulanic acid	1.0/0.5 – 32/16	≤ 8/4	16/8	≥ 32/16
	Ceftiofur	0.12 – 8	≤ 2	4	≥ 8
	Ceftriaxone	0.25 – 64	≤ 1	2	≥ 4
	Ciprofloxacin	0.015 – 4	≤ 1	2	≥ 4
II	Amikacin	0.5 – 32	≤ 16	32	≥ 64
	Ampicillin	1 – 32	≤ 8	16	≥ 32
	Cefoxitin	0.5 – 32	≤ 8	16	≥ 32
	Gentamicin	0.25 – 16	≤ 4	8	≥ 16
	Kanamycin	8 – 64	≤ 16	32	≥ 64
	Nalidixic acid	0.5 – 32	≤ 16	N/A	≥ 32
	Streptomycin[b]	32 – 64	≤ 32	N/A	≥ 64
	Trimethoprim-sulfamethoxazole	0.12/2.38 – 4/76	≤ 2/38	N/A	≥ 4/76
III	Chloramphenicol	2 – 32	≤ 8	16	≥ 32
	Sulfisoxazole	16 – 512	≤ 256	N/A	≥ 512
	Tetracycline	4 – 32	≤ 4	8	≥ 16
IV					

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

S = Susceptible. I = Intermediate susceptibility. R = Resistant. N/A = Not applicable.

[a] CLSI M100-S20.

[b] No Clinical and Laboratory Standards Institute interpretive criteria for Enterobacteriaceae were available for this antimicrobial. Breakpoints were based on the distribution of minimal inhibitory concentrations and were harmonized with those of the National Antimicrobial Resistance Monitoring System.

TABLE A.3. Breakpoints in antimicrobial susceptibility of *Enterococcus* isolates; CMV2AGPF plate, 2008.

	Antimicrobial	Range tested (μg/mL)	Breakpoints[a] (μg/mL)		
			S	I	R
I	Ciprofloxacin	0.12 – 4	≤ 1	2	≥ 4
	Daptomycin[b]	0.5 – 16	≤ 4	N/A	N/A
	Linezolid	0.5 – 8	≤ 2	4	≥ 8
	Tigecycline[c]	0.015 – 0.5	≤ 0.25	0.5	≥ 1
	Vancomycin	0.5 – 32	≤ 4	8-16	≥ 32
II	Erythromycin	0.5 – 8	≤ 0.5	1-4	≥ 8
	Gentamicin (high-level)	128 – 1,024	≤ 500	N/A	> 500
	Kanamycin (high-level)[b]	128 – 1,024	≤ 512	N/A	≥ 1,024
	Lincomycin[b]	1 – 32	≤ 2	4	≥ 8
	Penicillin	0.5 – 16	≤ 8	N/A	≥ 16
	Quinupristin-dalfopristin	1 – 32	≤ 1	2	≥ 4
	Streptomycin (high-level)[b]	512 – 2,048	≤ 1,000	N/A	> 1,000
	Tylosin[b]	0.25 – 32	≤ 8	16	≥ 32
III	Chloramphenicol	2 – 32	≤ 8	16	≥ 32
	Nitrofurantoin	2 – 64	≤ 32	64	≥ 128
	Tetracycline	4 – 32	≤ 4	8	≥ 16
IV	Flavomycin[b]	1 – 16	≤ 8	16	≥ 32

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

S = Susceptible. I = Intermediate resistance. R = Resistant. N/A = Not applicable.

[a] CLSI M100-S18 Table 2D. M7-A7-MIC Testing section.

[b] No Clinical and Laboratory Standards Institute (CLSI) interpretive criteria for *Enterococcus* were available for this antimicrobial. Breakpoints were based on the distribution of minimal inhibitory concentrations and were harmonized with those of the National Antimicrobial Resistance Monitoring System.

[c] Based on the resistance breakpoint from the European Committee on Antimicrobial Susceptibility Testing because no interpretative criteria were available from the CLSI for tigecycline.

TABLE A.4. Breakpoints in antimicrobial susceptibility of *Campylobacter* isolates; CAMPY plate, 2008.

	Antimicrobial	Range tested (μg/mL)	Breakpoints[a] (μg/mL)		
			S	I	R
I	Ciprofloxacin	0.015 – 64	≤ 1	2	≥ 4
	Telithromycin[b]	0.015 – 8	≤ 4	8	≥ 16
II	Azithromycin[b]	0.015 – 64	≤ 2	4	≥ 8
	Clindamycin[b]	0.03 – 16	≤ 2	4	≥ 8
	Erythromycin	0.03 – 64	≤ 8	16	≥ 32
	Gentamicin[b]	0.12 – 32	≤ 2	4	≥ 8
	Nalidixic acid[b]	4 – 64	≤ 16	32	≥ 64
III	Florfenicol[b,c]	0.03 – 64	≤ 4	N/A	N/A
	Tetracycline	0.06 – 64	≤ 4	8	≥ 16
IV					

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

S = Susceptible. I = Intermediate susceptibility. R = Resistant. N/A = Not applicable.

[a] CLSI M45-A.

[b] No Clinical and Laboratory Standards Institute interpretive criteria for *Campylobacter* were available for this antimicrobial. Breakpoints were based on the distribution of minimal inhibitory concentrations and were harmonized with those of the National Antimicrobial Resistance Monitoring System.

[c] No resistance breakpoint was defined at the time this report was prepared.

Antimicrobial Resistance Data Analysis for Human and Agri-Food Isolates

Data from human and agri-food surveillance were integrated and maintained in 2 computer repositories (Oracle®, Oracle Corp., Redwood Shores, CA, USA) and then transferred to a harmonized database (SAS® 9.1, SAS Institute Inc., Cary, NC, USA). For the *Farm Surveillance* component of CIPARS, the bacterial species, serovar, and MIC data were maintained in a relational database (Microsoft® Access, Microsoft Corp., Redmond, WA, USA).

Data were analyzed with statistical software programs (SAS® 9.1; and Stata® 8, Stata Corp., College Station, TX, USA), and outputs were exported into a spreadsheet application (Microsoft® Excel 2000, Microsoft Corp.). All tables and figures were generated with the spreadsheet application (Microsoft® Excel 2000). For *Farm Surveillance*, statistical analyses were performed to account for clustering of antimicrobial resistance within swine herds through generalized estimating equations (PROC GENMOD, SAS® 9.1). All statistical models for pig farms had a binary outcome, logit-link function, and an exchangeable correlation structure. Exact confidence intervals were computed by use of the BINOMIAL statement in PROC FREQ (SAS® 9.1) and an alpha level of 0.05. When the prevalence was 0%, an alpha level of 0.1 was used instead.

For the *Farm Surveillance*, *Abattoir Surveillance*, and *Retail Meat Surveillance* components, recovery rate was defined as the number of positive culture results divided by the total number of samples submitted for culture.

The percentage of isolates with resistance to antimicrobials was defined as the number of isolates resistant divided by the total number of isolates tested for each antimicrobial. The breakpoints used for the interpretation of antimicrobial susceptibility results are listed in Table A.2, Table A.3, and Table A.4. Intermediate MIC values were categorized as susceptible for all analyses. A new ceftriaxone breakpoint was officially adopted by the CLSI in January 2010. This new breakpoint was applied to all data, including historical data, and was used to perform the analysis for the 2008 Annual Report. The total number of antimicrobials in each resistance pattern was calculated by summing the number of antimicrobials to which each isolate was resistant.

For the provincial human incidence data, the number of *Salmonella* clinical cases in which a particular serovar was detected per 100,000 inhabitant-years was calculated by dividing the total number of isolates of each serovar received by CIPARS from that province by the provincial population (Statistics Canada post-census population estimates, Jan. 1, 2005) and then multiplying by 100,000. The national estimates for all serovars except *S.* Typhi and *S.* Newport were calculated as follows. In more heavily populated provinces, the number of isolates resistant and the total number of submitted isolates were multiplied by 2 each month. The numbers of isolates resistant (estimated value in larger provinces or actual value in smaller provinces) for all provinces were summed to obtain the total estimated number of isolates resistant. Total numbers of isolates submitted (estimated value in larger provinces or actual value in smaller provinces) for all provinces were summed to obtain the total estimated number of submissions. Finally, the total estimated number of isolates resistant was divided by the total estimated number of submissions for each antimicrobial tested to obtain a national estimate of resistance for each antimicrobial and each serovar.

Temporal analyses were performed for selected antimicrobials. Only 1 antimicrobial per antimicrobial class was selected among those antimicrobials commonly used in the agri-food and/or human sectors. Some antimicrobials were excluded from the temporal analyses for the following reasons:

- Resistance to the antimicrobial was absent or at a very low prevalence, or the breakpoint was debatable, and other antimicrobials could be used to provide a surrogate measure of resistance or intermediate susceptibility (e.g. nalidixic acid for ciprofloxacin).
- The isolate had cross-resistance to another selected antimicrobial (e.g. amoxicillin-clavulanic acid and ceftiofur).
- The antimicrobial is banned for use in the agri-food sector, and resistance to this drug is maintained because of the use of another drug (e.g. chloramphenicol).

A logistic regression model was developed with year as an independent categorical variable. Data were analyzed with commercial software (Stata 9.1®; or R version 2.2.1, R Foundation for Statistical Computing, Vienna, Austria). Firth's penalized maximum likelihood estimation was performed (R version 2.2.1) when data separation (1 or more zero cells in the contingency table) was encountered. In most situations, the year 2003 was selected as the baseline period; therefore, comparisons between 2003 and 2008 were performed. Comparisons between 2004 and 2008 were also performed for resistance to ampicillin and ceftiofur in *E. coli* and *Salmonella* isolated from chicken samples to assess changes in antimicrobial resistance after the early 2005 voluntary withdrawal of ceftiofur by Québec chicken hatcheries. The year 2004 was also used as a reference for temporal comparisons of ceftiofur and ampicillin resistance in human *S.* Heidelberg isolates because *S.* Heidelberg in humans was suspected to be mainly of chicken origin. For analyses of temporal variations in retail data from Saskatchewan, 2005 was used as the comparison year because this was the first year of CIPARS retail surveillance in that province. At the request of data users, comparisons between 2007 (past year of surveillance) and current year 2008 are also presented in this report. For temporal analysis of ceftiofur and ampicillin resistance in *Salmonella* and *E. coli* from retail chicken, the year 2006 was compared with 2008 because of changes in use of those drugs in 2007. Values of $P \leq 0.05$ were considered significant for all analyses.

Null binomial response models were used to estimate the prevalence of resistance to each antimicrobial. From each model, the intercept ($ß_0$) and 95% confidence intervals were used to calculate population-averaged prevalence estimates with the formula $[1 + \exp(-ß_0)]^{-1}$.

Data Collection and Analysis

Humans

Canadian CompuScript (CCS) is a database that records the number of prescriptions and number of units of product dispensed by pharmacists to consumers in Canada. Data fields include product name (including manufacturer), form, and strength as well as province, number of prescriptions, units of product, and dollars spent by month for each year.

The sampling frame (or "universe") for this dataset in 2008 consisted of approximately 7,980 pharmacies, covering nearly all retail pharmacies in Canada and excluding those in the Yukon, Northwest Territories, and Nunavut. The company Intercontinental Medical Statistics (IMS) Health uses a method of geospatial projection that creates projection factors for application to all non-participating stores on the basis of the number of stores in the area, distance between stores, and store size. In 2008, an average of 5,092 stores was included. The projection factor was used to extrapolate the number of prescriptions dispensed in the stores actually sampled to that of the "universe" (7,980 pharmacies).

Drugs were classified and defined daily doses (DDDs) were determined according to the Anatomical Therapeutic Chemical (ATC) classification system (Table A.5). Temporary DDDs (not yet approved but posted on the World Health Organization website) were used when available. For pediazole, the DDD for erythromycin ethyl succinate (2 g) was used. For oral administration of penicillin G, the DDD for benzylpenicillin by parenteral route (3.6 g) was used. Drugs with no DDDs were excluded, including trisulfaminic (drug discontinued in 2001; a total of 832,384 extended units were dispensed in 2000).

Although no hospital pharmacies participated in the CCS program, CCS data included a small volume of antimicrobials administered in non-oral forms such as injectable drugs or products administered by inhalation. Inconsistencies related to non-oral drugs, which represent a very small volume of the CCS data, were judged too common to include these drugs in the CIPARS analysis. Consequently, the 2008 report only describes orally administered drugs dispensed only by retail pharmacies. Only information regarding drugs of ATC group J01 (antimicrobials for systemic use) were retained in the analysis. Information regarding orally administered vancomycin (ATC group A07AA) was included in the analysis under class J01XA.

The total amount of active ingredient was obtained by multiplying the number of extended units (real or corrected) by the strength of the product in grams. For combination drugs, the active ingredients of all antimicrobial components were summed to obtain the total number of active ingredients. However, the amount of active ingredient used in the calculation of the total number of DDDs for combination drugs included only the compounds from which the DDDs were derived. For example, for drugs composed of trimethoprim-sulfamethoxazole, only the total number of grams of sulfamethoxazole was used to compute the number of DDDs.

The total number of DDDs per 1,000 inhabitant-days for a given year was obtained by summing all DDDs for each ATC class and each year. This number was further divided by the size of the population in thousands during that year, divided by the number of days in that year (365 or 366). The total number of prescriptions and total cost per 1,000 inhabitants was obtained by dividing the total number of prescriptions or the total cost by the population size in thousands for each year. Population data were obtained from updated and preliminary post-census estimates based on the results of the 2001 Census. Census counts were adjusted for net under-coverage (Statistics Canada).

In the 2002 and 2003 CIPARS reports, methenamine and linezolid were classified under "other antimicrobials." As of 2004, they have been reported separately to harmonize with reports from other surveillance programs such as the Danish Integrated Antimicrobial Resistance Monitoring and Research Program. The use of metronidazole (under J01XD imidazole) was added in 2005. Data from metronidazole could not be extracted at the time of analysis for year 2000. That information is therefore missing from the tables and is not included in any totals for year 2000.

Data were analyzed with statistical software programs (SAS® 9.1, SAS Institute Inc., Cary, NC, USA; Stata® 8, Stata Corp., College Station, TX, USA), and outputs were exported into a spreadsheet application (Microsoft® Excel 2000, Microsoft Corp., Redmond, WA, USA).

TABLE A.5. List of antimicrobials from the CompuScript database for each ATC[1] class.

	ATC code	ATC class	Antimicrobial
I	J01CR	Combinations of penicillins, including β-lactamase inhibitors	Amoxicillin-clavulanic acid
	J01DD	Third generation cephalosporins	Cefixime
	J01MA	Fluoroquinolones	Ciprofloxacin, gatifloxacin, grepafloxacin, levofloxacin, moxifloxacin, norfloxacin, ofloxacin, trovafloxacin
	J01XA	Glycopeptides	Vancomycin
	J01XD	Imidazoles	Metronidazole
	J01XX	Linezolid	Linezolid
II	J01CA	Penicillins with extended spectrum	Amoxicillin, ampicillin, bacampicillin, pivampicillin, pivmecillinam
	J01CE	β-lactamase sensitive penicillins	Penicillin G, penicillin V
	J01CF	β-lactamase resistant penicillins	Cloxacillin, dicloxacillin, flucloxacillin
	J01DB	First generation cephalosporins	Cefadroxil, cephalexin, cephradine
	J01DC	Second generation cephalosporins	Cefaclor, cefprozil, cefuroxime axetil
	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	Sulfadiazine-trimethoprim, sulfamethoxazole-trimethoprim
	J01FA	Macrolides	Azithromycin, clarithromycin, erythromycin, spiramycin, telithromycine
	J01FF	Lincosamides	Clindamycin, lincomycin
	J01GB	Aminoglycosides	Neomycin
	J01MB	Other quinolones	Nalidixic acid
	J01RA	Sulfonamide combinations, excluding trimethoprim	Erythromycin-sulfisoxazole
	J01XC	Steroid antibacterials	Fusidic acid
III	J01AA	Tetracyclines	Demeclocycline, doxycycline, minocycline, tetracycline
	J01BA	Amphenicols	Chloramphenicol
	J01EA	Trimethoprim and derivatives	Trimethoprim
	J01EB	Short-acting sulfonamides	Sulfamethizole, sulfapyridine, sulfisoxazole
	J01EC	Intermediate-acting sulfonamides	Phenazopyridine-sulfamethoxazole, sulfadiazine, sulfamethoxazole
	J01XE	Nitrofuran derivatives	Nitrofurantoin
	J01XX	Fosfomycin	Fosfomycin
NC	J01XX	Methenamine	Methenamine, methenamine-sodium-tartaric acid

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

ATC = Anatomical Therapeutic Chemical. NC = Not classified.

[1] World Health Organization Collaborating Center for Drug Statistics Methodology. Available at: www.whocc.no/atcddd. Accessed October 2010.

Farm Surveillance in Pigs

The selection of swine herds is described in the subsection Antimicrobial Resistance in the Agri-Food Sector under *Farm Surveillance* (Appendix A). Data regarding these participating herds were collected through questionnaires completed by veterinarians, owners, or managers of the herds. The questionnaires included questions on antimicrobial use (AMU) within each herd, health of pigs, and farm characteristics.

The questionnaire for AMU was designed to collect data for herds of pigs in the grower-finisher production phase. No data on individual pigs were collected. Two pens representative of this population were selected for the collection of fecal specimens for bacterial culture and antimicrobial susceptibility testing. Thus, in herds with all-in-all-out (or batch) management, the population of interest included all pigs that entered and exited the barn in the same group as the sampled pigs. For herds with continuous-flow management, the population of interest for the first sampling period was defined as the grower-finisher pigs that were in the barn 4 months before the first fecal specimens were collected. In subsequent sampling periods, the population of interest was those pigs that had moved into the grower-finisher barn since the previous set of specimens was collected. The interval between sampling points was approximately 4 months (mean, 4.3 months; standard deviation, 2.1 months). The weight of pigs entering the grower-finisher production phase varied among herds.

Questions pertaining to the population of interest slightly varied in questionnaires, depending on whether continuous-flow management or all-in-all-out management was used, in order to accurately describe these different systems. All-in-all-out pig flow is a production system whereby animals are moved into and out of facilities in distinct groups. By preventing the commingling of groups, the hope is to reduce the spread of disease. Facilities are normally cleaned and disinfected thoroughly between groups of animals. This type of management is generally by room or by barn. In continuous-flow operations, animals are continually being removed and added and there is no distinct group of animals that stays together within each phase of production.

Herd owners/managers were asked about antimicrobial use (AMU) via feed, water, and injections. Data were collected on each diet fed to each population of interest, including diets that contained no antimicrobials. Because all pigs in each population of interest were exposed to the same diets, data on the number of pigs exposed to antimicrobials through feed were not collected. Diet-specific data included weight of the pigs at the start and end of the diet and duration of exposure and tonnes consumed for each diet. The following additional information was collected for diets containing antimicrobials: active ingredient(s), antimicrobial concentration(s), and reason(s) for AMU (categories included enteric disease, lameness, respiratory disease, disease prevention, growth promotion, and other). Exposure to antimicrobials though water was described by the active ingredient(s) of the drug(s), weight of the pigs at the start and end of exposure, duration of exposure, number of pigs exposed, and reason(s) for AMU. Data collected on AMU through injection included active ingredient(s) of the drug(s), the number of pigs exposed, and the reason(s) for AMU. No AMU data were collected for any production phase prior to the grower-finisher phase. Any data describing AMU in pigs weighing less than 15 kg were excluded because this weight is considered below the industry standard for grower-finisher pigs.

Antimicrobial exposures were summarized for each herd. An exposure was defined as any reported use of an active ingredient by a given administration route in 2008. Data were described by exposure to an active ingredient by a given administration route, as well as by exposure to an active ingredient by any administration route. These exposures were summarized by antimicrobial class.[1] It is important to note that typically, treatment through feed tends to be administered to a larger group of pigs and for longer periods than water treatment, whereas injectable drugs are generally administered on an individual basis to a limited number of pigs.

[1] Veterinary Drugs Directorate. Categorization of Antimicrobial Drugs Based on Importance in Human Medicine. Version of April, 2009. Available at: www.hc-sc.gc.ca/dhp-mps/consultation/vet/consultations/amr_ram_hum-med_e.html. Accessed October 2010.

Data were entered into a database, and all descriptive statistics were obtained with commercially available software (Microsoft Excel® 2003 and Microsoft Access® 2003 [Microsoft Corp., Redmond, WA, USA] and Intercooled Stata® version 9.2 [R Foundation for Statistical Computing, Vienna, Austria]).

Data on AMU were provided for every herd for every route of antimicrobial administration. In Canada, pigs are typically maintained in the grower-finisher production phase for 16 to 20 weeks, and therefore the replacement rate of pigs in a grower-finisher barn is approximately 3 times per year. The surveillance program was designed for administration of the AMU questionnaire to each herd 3 times annually, at approximately 4-month intervals, so AMU during the calendar year could be described.

Data from the AMU questionnaires were compiled so that any reported exposure mentioned in a single questionnaire was classified as an exposure in that herd in 2008. The questionnaires were designed to collect quantitative AMU data for antimicrobial exposures through feed and water, but not through injection. However, the results reported in the CIPARS annual report are solely qualitative and do not include exposure rate, duration, or dose of antimicrobial.

Appendix B – Minimal Inhibitory Concentration Tables

The following information is important for the interpretation of tables presenting results on the distribution of minimal inhibitory concentrations (MICs).

- Roman numerals I to IV indicate the ranking of human medicine importance as outlined by the Veterinary Drugs Directorate, Health Canada.
- The unshaded fields indicate the range tested for each antimicrobial in the plate configuration.
- Red numbers indicate the percentage of isolates that were resistant to the antimicrobial according to the predefined resistance breakpoint.
- Numbers to the right of the highest concentration in the tested range (i.e. red numbers in shaded fields) represent the percentage of isolates with growth in all wells within the tested range, indicating that the actual MICs were greater than the tested range of concentrations.
- Numbers at the lowest concentration in the tested range (i.e. blue numbers at the far left in unshaded fields) represent the percentage of isolates susceptible to the antimicrobial at the indicated or lower concentrations.
- Solid vertical lines represent resistance breakpoints.
- Dotted vertical lines represent susceptibility breakpoints.
- MIC 50 = MIC at which 50% of isolates were inhibited by a specific antimicrobial.
- MIC 90 = MIC at which 90% of isolates were inhibited by a specific antimicrobial.
- %R = Percentage of isolates that were resistant to a specific antimicrobial.

Humans

TABLE B.1. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* Enteritidis isolates from humans; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	1,258	≤ 1	≤ 1	0.2							94.5	2.9	0.3	1.9	0.1	0.2	0.1			
	Ceftiofur	1,258	1	1	0.2				0.2	0.2	3.3	94.8	1.5			0.2					
	Ceftriaxone	1,258	≤ 0.25	≤ 0.25	0.2					99.7	0.2					0.2					
	Ciprofloxacin	1,258	≤ 0.015	0.12	0.0	82.4	3.7	0.3	7.4	4.7	1.5										
II	Amikacin	1,258	1	2	0.0						12.8	75.4	11.3	0.5							
	Ampicillin	1,258	≤ 1	≤ 1	2.6							90.5	6.4	0.6				2.6			
	Cefoxitin	1,258	2	2	0.2							3.6	89.2	6.2	0.8		0.2	0.1			
	Gentamicin	1,258	≤ 0.25	0.50	0.2					68.5	30.0	1.2				0.2	0.1				
	Kanamycin	1,258	≤ 8	≤ 8	0.2										99.8				0.2		
	Nalidixic acid	1,258	4	> 32	12.6								24.2	61.1	1.0	1.1	0.2	12.3			
	Streptomycin	1,258	≤ 32	≤ 32	0.9												99.1	0.2	0.7		
	Trimethoprim-sulfamethoxazole	1,258	≤ 0.12	0.25	0.4				86.2	12.8	0.6			0.1	0.3						
III	Chloramphenicol	1,258	4	8	0.1								0.6	59.5	39.5	0.3		0.1			
	Sulfisoxazole	1,258	32	64	1.0											3.0	64.0	31.4	0.5	0.2	1.0
	Tetracycline	1,258	≤ 4	≤ 4	1.6									98.4		0.1	0.1	1.4			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.2. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* Heidelberg isolates from humans; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	290	≤ 1	32	13.4							66.6	1.7	0.3	4.1	13.8	7.9	5.5			
	Ceftiofur	290	1	> 8	14.1				0.3		23.4	61.7	0.3		0.3	13.8					
	Ceftriaxone	290	≤ 0.25	16	14.1					85.9				0.3	0.3	11.4	1.7	0.3			
	Ciprofloxacin	290	≤ 0.015	≤ 0.015	0.0	99.7	0.3														
II	Amikacin	290	1	2	0.0						1.0	53.8	40.7	4.5							
	Ampicillin	290	≤ 1	> 32	31.7							67.2	1.0					31.7			
	Cefoxitin	290	2	32	13.1							31.7	49.0	5.2	0.7	0.3	4.5	8.6			
	Gentamicin	290	0.50	0.50	2.4					27.6	63.4	6.2	0.3			0.3	2.1				
	Kanamycin	290	≤ 8	≤ 8	1.0										98.6	0.3			1.0		
	Nalidixic acid	290	2	4	0.0								62.1	37.6	0.3						
	Streptomycin	290	≤ 32	≤ 32	6.9												93.1	4.1	2.8		
	Trimethoprim-sulfamethoxazole	290	≤ 0.12	0.25	1.4				77.6	20.7			0.3	0.3	1.0						
III	Chloramphenicol	290	8	8	0.7									16.9	81.7	0.7		0.7			
	Sulfisoxazole	290	32	64	3.8											22.1	67.6	6.6			3.8
	Tetracycline	290	≤ 4	≤ 4	6.2									93.8				6.2			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.3. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* Newport isolates from humans; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	177	≤ 1	≤ 1	1.1							96.6	0.6		1.7			1.1			
	Ceftiofur	177	1	1	1.7				0.6		27.7	70.1				1.7					
	Ceftriaxone	177	≤ 0.25	≤ 0.25	1.7					98.3							0.6	0.6	0.6		
	Ciprofloxacin	177	≤ 0.015	≤ 0.015	0.0	98.9			0.6	0.6											
II	Amikacin	177	1	2	0.0						0.6	60.5	37.9	1.1							
	Ampicillin	177	≤ 1	≤ 1	2.8							95.5	1.7					2.8			
	Cefoxitin	177	2	2	1.1						0.6	10.7	81.4	5.6	0.6			1.1			
	Gentamicin	177	0.50	0.50	0.6					27.7	69.5	1.1	1.1				0.6				
	Kanamycin	177	≤ 8	≤ 8	0.6										99.4				0.6		
	Nalidixic acid	177	2	4	1.1							1.1	71.8	26.0				1.1			
	Streptomycin	177	≤ 32	≤ 32	2.3												97.7	0.6	1.7		
	Trimethoprim-sulfamethoxazole	177	≤ 0.12	0.25	1.1				85.9	13.0					1.1						
III	Chloramphenicol	177	4	8	1.7								1.7	82.5	14.1			1.7			
	Sulfisoxazole	177	64	64	2.8											2.8	38.4	52.0	3.4	0.6	2.8
	Tetracycline	177	≤ 4	≤ 4	4.0									96.0		0.6		3.4			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.4. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* Paratyphi A and *S.* Paratyphi B isolates from humans; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	65	≤ 1	2	3.1							55.4	40.0			1.5	3.1				
	Ceftiofur	65	1	1	1.5						6.2	90.8	1.5			1.5					
	Ceftriaxone	65	≤ 0.25	≤ 0.25	1.5					98.5						1.5					
	Ciprofloxacin	65	0.50	0.50	0.0	26.2	1.5				70.8	1.5									
II	Amikacin	65	0.50	1	0.0						75.4	15.4	9.2								
	Ampicillin	65	2	2	4.6							16.9	76.9		1.5			4.6			
	Cefoxitin	65	4	8	1.5							4.6	12.3	69.2	12.3			1.5			
	Gentamicin	65	≤ 0.25	0.50	1.5					83.1	12.3	3.1					1.5				
	Kanamycin	65	≤ 8	≤ 8	1.5										98.5				1.5		
	Nalidixic acid	65	> 32	> 32	72.3								10.8	16.9				72.3			
	Streptomycin	65	≤ 32	≤ 32	4.6												95.4		4.6		
	Trimethoprim-sulfamethoxazole	65	≤ 0.12	0.25	1.5				58.5	40.0					1.5						
III	Chloramphenicol	65	8	8	4.6									9.2	84.6	1.5		4.6			
	Sulfisoxazole	65	32	64	4.6											7.7	75.4	12.3			4.6
	Tetracycline	65	≤ 4	≤ 4	6.2									93.8			1.5	4.6			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.5. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* Typhi isolates from humans; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	186	≤ 1	8	0.0							82.8	0.5	1.1	11.3	4.3					
	Ceftiofur	186	0.50	1	0.0				1.1	2.2	75.3	21.5									
	Ceftriaxone	186	≤ 0.25	≤ 0.25	0.0					100.0											
	Ciprofloxacin	186	0.25	0.25	0.0	16.1		11.8	14.5	51.1	5.9		0.5								
II	Amikacin	186	1	1	0.0						10.2	85.5	4.3								
	Ampicillin	186	≤ 1	> 32	16.7							82.8	0.5					16.7			
	Cefoxitin	186	4	8	0.0						1.1	20.4	13.4	53.2	11.8						
	Gentamicin	186	≤ 0.25	0.50	0.0					82.3	17.2	0.5									
	Kanamycin	186	≤ 8	≤ 8	0.5										99.5				0.5		
	Nalidixic acid	186	> 32	> 32	69.4							1.1	13.4	14.5	1.6			69.4			
	Streptomycin	186	≤ 32	> 64	17.7												82.3	1.1	16.7		
	Trimethoprim-sulfamethoxazole	186	≤ 0.12	> 4	17.2				72.6	10.2					17.2						
III	Chloramphenicol	186	4	> 32	17.7								1.6	67.2	13.4			17.7			
	Sulfisoxazole	186	32	> 256	18.3											28.0	45.7	7.5	0.5		18.3
	Tetracycline	186	≤ 4	≤ 4	5.9									94.1				5.9			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.6. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* Typhimurium isolates from humans; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	474	≤ 1	16	2.5							68.4	0.8	1.5	11.2	15.6	0.8	1.7			
	Ceftiofur	474	1	1	2.3						10.3	85.7	1.7			2.3					
	Ceftriaxone	474	≤ 0.25	≤ 0.25	2.3					97.5	0.2					0.8	0.6	0.6	0.2		
	Ciprofloxacin	474	≤ 0.015	≤ 0.015	0.0	94.7	2.1		0.4	1.7	0.8	0.2									
II	Amikacin	474	2	2	0.0							46.4	51.1	2.5							
	Ampicillin	474	≤ 1	> 32	30.6							67.1	1.9	0.4			0.4	30.2			
	Cefoxitin	474	2	4	2.3							8.4	78.3	9.3	1.7		0.2	2.1			
	Gentamicin	474	0.50	1	2.5					13.3	74.9	9.3				0.2	2.3				
	Kanamycin	474	≤ 8	> 64	12.4										87.3	0.2		0.2	12.2		
	Nalidixic acid	474	2	4	2.1								61.4	34.8	1.5	0.2		2.1			
	Streptomycin	474	≤ 32	> 64	30.4												69.6	15.0	15.4		
	Trimethoprim-sulfamethoxazole	474	≤ 0.12	0.25	5.1				56.1	36.5	2.3			0.2	4.9						
III	Chloramphenicol	474	8	> 32	21.1								0.6	33.8	44.1	0.4		21.1			
	Sulfisoxazole	474	32	> 256	32.9											3.0	52.3	11.6	0.2		32.9
	Tetracycline	474	≤ 4	> 32	32.1									67.9		8.0	9.7	14.3			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.7. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* "Other Serovars" isolates from humans; *Surveillance of Human Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	1,151	≤ 1	≤ 1	1.7							91.4	1.7	1.0	2.1	2.3	0.4	1.2			
	Ceftiofur	1,151	1	1	1.8				0.1	0.3	28.7	67.2	1.7	0.2	0.2	1.7					
	Ceftriaxone	1,151	≤ 0.25	≤ 0.25	1.8					98.2				0.1	0.1	1.2	0.3	0.1	0.1		
	Ciprofloxacin	1,151	≤ 0.015	≤ 0.015	1.0	92.1	1.0	0.7	1.2	2.2	1.0	0.7	0.1		1.0						
II	Amikacin	1,151	1	2	0.0						1.0	53.4	43.0	2.4	0.2						
	Ampicillin	1,151	≤ 1	≤ 1	6.3							91.0	1.8	0.4	0.2	0.3		6.3			
	Cefoxitin	1,151	2	4	2.0							10.0	57.3	28.7	1.9	0.1	0.3	1.7			
	Gentamicin	1,151	0.50	0.50	2.4					22.7	68.7	5.7	0.3		0.1	0.6	1.8				
	Kanamycin	1,151	≤ 8	≤ 8	1.5										97.6	0.7	0.3	0.1	1.4		
	Nalidixic acid	1,151	2	4	4.9							0.4	65.5	26.7	1.8	0.7	0.1	4.8			
	Streptomycin	1,151	≤ 32	64	12.8												87.2	6.4	6.3		
	Trimethoprim-sulfamethoxazole	1,151	≤ 0.12	0.25	3.5				80.8	14.2	1.3		0.2		3.5						
III	Chloramphenicol	1,151	8	8	3.0								0.4	45.4	50.5	0.7	0.2	2.9			
	Sulfisoxazole	1,151	64	> 256	10.7											7.7	41.0	38.0	2.4	0.2	10.7
	Tetracycline	1,151	≤ 4	> 32	19.5									80.1	0.3	0.3	4.9	14.3			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.8. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from cattle; *Surveillance of Animal Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	134	≤ 1	16	4.5							61.9	3.7	1.5	11.9	16.4	1.5	3.0			
	Ceftiofur	134	1	1	4.5					0.7	30.6	59.0	5.2			4.5					
	Ceftriaxone	134	≤ 0.25	≤ 0.25	4.5					95.5							3.7	0.7			
	Ciprofloxacin	134	≤ 0.015	≤ 0.015	0.0	94.8	4.5			0.7											
II	Amikacin	134	1	2	0.0						5.2	53.7	36.6	3.7		0.7					
	Ampicillin	134	≤ 1	> 32	32.8							61.9	3.7	0.7	0.7			32.8			
	Cefoxitin	134	2	4	4.5							10.4	61.2	19.4	4.5		3.7	0.7			
	Gentamicin	134	0.50	1	6.0					48.5	38.1	6.7	0.7			3.7	2.2				
	Kanamycin	134	≤ 8	> 64	23.9										76.1			0.7	23.1		
	Nalidixic acid	134	4	4	0.0								40.3	56.0	3.7						
	Streptomycin	134	≤ 32	> 64	30.6												69.4	6.7	23.9		
	Trimethoprim-sulfamethoxazole	134	≤ 0.12	0.50	6.7				59.7	29.9	3.7				6.7						
III	Chloramphenicol	134	8	> 32	23.9								3.7	30.6	39.6	2.2	0.7	23.1			
	Sulfisoxazole	134	32	> 256	34.3											4.5	52.2	9.0			34.3
	Tetracycline	134	≤ 4	> 32	32.8									67.2			4.5	28.4			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.9. Distribution of minimal inhibitory concentrations for antimicrobials in *Escherichia coli* isolates from beef cattle; *Abattoir Surveillance*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	176	4	4	0.0							7.4	33.5	52.8	6.3						
	Ceftiofur	176	0.25	0.50	0.0				7.4	51.1	40.9	0.6									
	Ceftriaxone	176	≤ 0.25	≤ 0.25	0.0					100.0											
	Ciprofloxacin	176	≤ 0.015	≤ 0.015	0.0	97.7	2.3														
II	Amikacin	176	2	2	0.0						1.1	26.7	62.5	8.0	1.7						
	Ampicillin	176	2	4	1.1							19.9	54.0	23.3	1.7			1.1			
	Cefoxitin	176	4	8	0.0							3.4	27.3	57.4	10.2	1.7					
	Gentamicin	176	0.50	0.50	0.0					8.5	83.0	8.0	0.6								
	Kanamycin	176	≤ 8	≤ 8	2.8										97.2				2.8		
	Nalidixic acid	176	2	4	0.0						0.6	14.2	73.3	10.8		1.1					
	Streptomycin	176	≤ 32	64	14.8												85.2	8.0	6.8		
	Trimethoprim-sulfamethoxazole	176	≤ 0.12	0.25	0.0				73.9	23.9	2.3										
III	Chloramphenicol	176	8	8	2.8								2.3	42.0	50.0	2.8		2.8			
	Sulfisoxazole	176	≤ 16	> 256	15.3											80.7	2.8		1.1		15.3
	Tetracycline	176	≤ 4	> 32	37.5									52.8	9.7	7.4	4.0	26.1			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.10. Distribution of minimal inhibitory concentrations for antimicrobials in *Escherichia coli* isolates from beef, by province/region; *Retail Meat Surveillance*, 2008.

	Antimicrobial	Province/region	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
				MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	Amoxicillin-clavulanic acid	British Columbia	88	4	8	2.3							9.1	30.7	45.5	11.4	1.1	1.1	1.1			
		Saskatchewan	134	4	4	0.7							4.5	30.6	59.7	4.5			0.7			
		Ontario	185	4	4	1.1							7.0	35.1	48.6	7.0	1.1	0.5	0.5			
		Québec	126	4	4	0.8							9.5	31.7	54.8	3.2			0.8			
		Maritimes	39	4	4	2.6							5.1	38.5	53.8			2.6				
	Ceftiofur	British Columbia	88	0.25	0.50	2.3				10.2	43.2	44.3					2.3					
		Saskatchewan	134	0.25	0.50	0.7				6.7	47.8	44.8				0.7						
		Ontario	185	0.25	0.50	1.1				7.6	55.7	35.7					1.1					
		Québec	126	0.25	0.50	0.8				11.1	46.8	40.5	0.8			0.8						
I		Maritimes	39	0.25	0.50	2.6				2.6	56.4	35.9	2.6			2.6						
	Ceftriaxone	British Columbia	88	≤ 0.25	≤ 0.25	2.3					97.7						2.3					
		Saskatchewan	134	≤ 0.25	≤ 0.25	0.7					99.3					0.7						
		Ontario	185	≤ 0.25	≤ 0.25	1.1					98.4		0.5				1.1					
		Québec	126	≤ 0.25	≤ 0.25	0.8					99.2						0.8					
		Maritimes	39	≤ 0.25	≤ 0.25	2.6					97.4					2.6						
	Ciprofloxacin	British Columbia	88	≤ 0.015	≤ 0.015	0.0	97.7	2.3														
		Saskatchewan	134	≤ 0.015	≤ 0.015	0.0	100.0															
		Ontario	185	≤ 0.015	≤ 0.015	0.0	99.5	0.5														
		Québec	126	≤ 0.015	≤ 0.015	0.0	99.2	0.8														
		Maritimes	39	≤ 0.015	≤ 0.015	0.0	100.0															
	Amikacin	British Columbia	88	2	2	0.0							31.8	62.5	5.7							
		Saskatchewan	134	2	2	0.0							29.1	65.7	5.2							
		Ontario	185	2	2	0.0						0.5	23.2	70.3	5.9							
		Québec	126	2	4	0.0							29.4	57.1	11.1	2.4						
		Maritimes	39	2	2	0.0						5.1	35.9	59.0								
	Ampicillin	British Columbia	88	2	4	5.7							21.6	47.7	23.9		1.1		5.7			
		Saskatchewan	134	2	4	0.7							14.9	57.5	26.9				0.7			
		Ontario	185	2	4	5.9							18.4	55.7	19.5	0.5			5.9			
		Québec	126	2	4	2.4							16.7	56.3	23.0	1.6			2.4			
		Maritimes	39	2	4	2.6							12.8	51.3	33.3				2.6			
	Cefoxitin	British Columbia	88	4	8	2.3						1.1	5.7	22.7	56.8	9.1	2.3		2.3			
		Saskatchewan	134	4	8	0.7							3.7	26.9	59.0	9.7			0.7			
		Ontario	185	4	4	1.6							2.7	31.4	56.8	7.6		0.5	1.1			
		Québec	126	4	4	0.8							7.1	28.6	55.6	7.9			0.8			
		Maritimes	39	4	4	2.6							2.6	28.2	61.5	5.1		2.6				
	Gentamicin	British Columbia	88	0.50	1	0.0					14.8	71.6	13.6									
		Saskatchewan	134	0.50	0.50	0.0					10.4	80.6	8.2	0.7								
		Ontario	185	0.50	1	1.1					9.2	75.7	13.5	0.5				1.1				
		Québec	126	0.50	1	0.0					9.5	69.8	19.8	0.8								
		Maritimes	39	0.50	1	0.0					33.3	56.4	10.3									
II	Kanamycin	British Columbia	88	≤ 8	≤ 8	2.3										97.7				2.3		
		Saskatchewan	134	≤ 8	≤ 8	0.7										99.3				0.7		
		Ontario	185	≤ 8	≤ 8	1.6										98.4				1.6		
		Québec	126	≤ 8	≤ 8	4.8										94.4	0.8			4.8		
		Maritimes	39	≤ 8	≤ 8	2.6										97.4				2.6		
	Nalidixic acid	British Columbia	88	2	4	0.0							10.2	72.7	17.0							
		Saskatchewan	134	2	2	0.0							4.5	85.8	9.7							
		Ontario	185	2	2	0.0						0.5	9.7	81.6	8.1							
		Québec	126	2	2	0.0							13.5	77.8	8.7							
		Maritimes	39	2	2	0.0							10.3	84.6	5.1							
	Streptomycin	British Columbia	88	≤ 32	≤ 32	9.1												90.9	5.7	3.4		
		Saskatchewan	134	≤ 32	≤ 32	5.2												94.8	1.5	3.7		
		Ontario	185	≤ 32	64	11.4												88.6	5.9	5.4		
		Québec	126	≤ 32	≤ 32	7.1												92.9	4.0	3.2		
		Maritimes	39	≤ 32	≤ 32	5.1												94.9		5.1		
	Trimethoprim-sulfamethoxazole	British Columbia	88	≤ 0.12	0.25	0.0				71.6	28.4											
		Saskatchewan	134	≤ 0.12	0.25	0.7				71.6	24.6	3.0				0.7						
		Ontario	185	≤ 0.12	0.25	3.2				65.9	27.6	3.2				3.2						
		Québec	126	≤ 0.12	0.25	0.8				75.4	22.2	1.6				0.8						
		Maritimes	39	≤ 0.12	0.25	2.6				66.7	28.2		2.6			2.6						
	Chloramphenicol	British Columbia	88	8	8	0.0								5.7	35.2	56.8	2.3					
		Saskatchewan	134	4	8	0.7								3.0	48.5	46.3	1.5		0.7			
		Ontario	185	8	8	3.2								4.3	44.3	47.0	1.1	0.5	2.7			
		Québec	126	4	8	0.8								6.3	46.8	41.3	4.8		0.8			
		Maritimes	39	4	8	0.0								2.6	53.8	43.6						
	Sulfisoxazole	British Columbia	88	≤ 16	32	9.1											79.5	11.4				9.1
		Saskatchewan	134	≤ 16	32	7.5											86.6	6.0				7.5
III		Ontario	185	≤ 16	> 256	13.0											81.6	4.9			0.5	13.0
		Québec	126	≤ 16	32	7.9											88.9	3.2				7.9
		Maritimes	39	≤ 16	32	2.6											87.2	7.7	2.6			2.6
	Tetracycline	British Columbia	88	≤ 4	> 32	22.7									70.5	6.8	2.3	3.4	17.0			
		Saskatchewan	134	≤ 4	> 32	20.1									76.1	3.7	3.7		16.4			
		Ontario	185	≤ 4	> 32	20.5									76.2	3.2	3.2	3.2	14.1			
		Québec	126	≤ 4	> 32	16.7									80.2	3.2	1.6	2.4	12.7			
		Maritimes	39	≤ 4	32	17.9									66.7	15.4		12.8	5.1			
IV																						

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.
The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

TABLE B.11. Distribution of minimal inhibitory concentrations for antimicrobials in *Campylobacter* isolates from beef cattle, by *Campylobacter* species; *Abattoir Surveillance*, 2008.

	Antimicrobial	Species	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)												
				MIC 50	MIC 90		≤ 0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	> 64
I	Ciprofloxacin	*Campylobacter coli*	30	0.125	0.25	3.3				53.3	43.3							3.3		
	Ciprofloxacin	*Campylobacter jejuni*	93	0.125	0.25	2.2			34.4	50.5	12.9					1.1		1.1		
	Ciprofloxacin	*Campylobacter* spp.	5	0.25	0.25	0.0				20.0	80.0									
	Telithromycin	*Campylobacter coli*	30	2	4	0.0								76.7	23.3					
	Telithromycin	*Campylobacter jejuni*	93	1	2	0.0					3.2	25.8	60.2	10.8						
	Telithromycin	*Campylobacter* spp.	5	0.5	4	0.0					40.0	40.0			20.0					
II	Azithromycin	*Campylobacter coli*	30	0.125	0.25	0.0				56.7	40.0	3.3								
	Azithromycin	*Campylobacter jejuni*	93	0.064	0.064	0.0	3.2	38.7	55.9	2.2										
	Azithromycin	*Campylobacter* spp.	5	0.064	0.5	0.0		20.0	40.0		20.0	20.0								
	Clindamycin	*Campylobacter coli*	30	1	1	0.0						33.3	63.3		3.3					
	Clindamycin	*Campylobacter jejuni*	93	0.125	0.25	0.0			10.8	50.5	31.2	7.5								
	Clindamycin	*Campylobacter* spp.	5	0.25	0.5	0.0				20.0	60.0	20.0								
	Erythromycin	*Campylobacter coli*	30	2	2	0.0							3.3	93.3	3.3					
	Erythromycin	*Campylobacter jejuni*	93	0.5	0.5	0.0				3.2	34.4	62.4								
	Erythromycin	*Campylobacter* spp.	5	0.5	1	0.0				20.0	20.0	40.0	20.0							
	Gentamicin	*Campylobacter coli*	30	0.5	1	0.0						70.0	30.0							
	Gentamicin	*Campylobacter jejuni*	93	1	1	0.0						46.2	52.7	1.1						
	Gentamicin	*Campylobacter* spp.	5	0.25	0.25	0.0				40.0	60.0									
	Nalidixic acid	*Campylobacter coli*	30	16	16	3.3										16.7	76.7	3.3		3.3
	Nalidixic acid	*Campylobacter jejuni*	93	≤ 4	8	2.2									68.8	29.0				2.2
	Nalidixic acid	*Campylobacter* spp.	5	64	> 64	60.0												40.0	20.0	40.0
III	Florfenicol	*Campylobacter coli*	30	2	2	0.0							20.0	80.0						
	Florfenicol	*Campylobacter jejuni*	93	1	1	0.0						20.4	74.2	5.4						
	Florfenicol	*Campylobacter* spp.	5	1	1	0.0					40.0		60.0							
	Tetracycline	*Campylobacter coli*	30	> 64	> 64	86.7							13.3							86.7
	Tetracycline	*Campylobacter jejuni*	93	64	> 64	60.2				18.3	17.2	4.3						2.2	32.3	25.8
	Tetracycline	*Campylobacter* spp.	5	16	32	60.0					20.0					20.0	40.0	20.0		
IV																				

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.
Campylobacter spp. include unidentified species, some of which may be intrinsically resistant to nalidixic acid.

Chickens

TABLE B.12. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from chickens; *Abattoir Surveillance*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	234	≤ 1	32	11.5							82.9	0.9		3.8	0.9	2.6	9.0			
	Ceftiofur	234	1	> 8	11.5						37.6	49.6	1.3		0.4	11.1					
	Ceftriaxone	234	≤ 0.25	8	11.5					87.6	0.9				1.7	8.1	1.7				
	Ciprofloxacin	234	≤ 0.015	0.03	0.0	84.6	15.0	0.4													
II	Amikacin	234	1	2	0.0						6.8	52.6	38.5	2.1							
	Ampicillin	234	≤ 1	> 32	16.2							79.9	3.4	0.4				16.2			
	Cefoxitin	234	2	32	10.7							22.2	50.9	14.1	0.9	1.3	6.4	4.3			
	Gentamicin	234	0.50	0.50	0.4					46.6	48.7	3.8		0.4			0.4				
	Kanamycin	234	≤ 8	≤ 8	0.4										99.6				0.4		
	Nalidixic acid	234	4	4	0.0						0.4	1.3	38.5	56.4	3.4						
	Streptomycin	234	≤ 32	> 64	39.7												60.3	20.9	18.8		
	Trimethoprim-sulfamethoxazole	234	≤ 0.12	0.25	0.0				87.6	11.1	1.3										
III	Chloramphenicol	234	4	8	0.4								5.1	56.0	38.0	0.4		0.4			
	Sulfisoxazole	234	32	64	3.0											14.1	65.0	16.7	1.3		3.0
	Tetracycline	234	≤ 4	> 32	41.0									59.0		0.4	2.6	38.0			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.13. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from chicken, by province/region; *Retail Meat Surveillance*, 2008.

	Antimicrobial	Province/region	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
				MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	Amoxicillin-clavulanic acid	British Columbia	47	≤ 1	> 32	21.3							68.1	4.3		4.3	2.1	4.3	17.0			
		Saskatchewan	64	≤ 1	≤ 1	4.7							90.6			4.7		1.6	3.1			
		Ontario	139	≤ 1	16	9.4							85.6	0.7		1.4	2.9	1.4	7.9			
		Québec	120	≤ 1	> 32	15.0							78.3	0.8		2.5	3.3	3.3	11.7			
		Maritimes	12	≤ 1	> 32	16.7							83.3						16.7			
	Ceftiofur	British Columbia	47	1	> 8	23.4						19.1	55.3	2.1		2.1	21.3					
		Saskatchewan	64	1	1	4.7						37.5	56.3	1.6			4.7					
		Ontario	139	1	8	10.1					0.7	40.3	48.2	0.7		0.7	9.4					
		Québec	120	1	> 8	15.0						38.3	45.8	0.8			15.0					
I		Maritimes	12	1	> 8	16.7						50.0	33.3				16.7					
	Ceftriaxone	British Columbia	47	≤ 0.25	16	23.4					76.6					6.4	12.8	4.3				
		Saskatchewan	64	≤ 0.25	≤ 0.25	4.7					95.3						3.1	1.6				
		Ontario	139	≤ 0.25	8	10.1					89.9					1.4	6.5	1.4	0.7			
		Québec	120	≤ 0.25	16	15.0					85.0					0.8	8.3	5.0	0.8			
		Maritimes	12	≤ 0.25	16	16.7					83.3						16.7					
	Ciprofloxacin	British Columbia	47	≤ 0.015	≤ 0.015	0.0	95.7	2.1	2.1													
		Saskatchewan	64	≤ 0.015	0.03	0.0	85.9	14.1														
		Ontario	139	≤ 0.015	0.03	0.0	87.1	12.9														
		Québec	120	≤ 0.015	0.03	0.0	82.5	16.7	0.8													
		Maritimes	12	≤ 0.015	≤ 0.015	0.0	100.0															
	Amikacin	British Columbia	47	1	4	0.0							61.7	27.7	10.6							
		Saskatchewan	64	1	2	0.0						14.1	51.6	32.8	1.6							
		Ontario	139	1	2	0.0						11.5	56.8	30.2	0.7	0.7						
		Québec	120	1	2	0.0						10.0	58.3	30.0	1.7							
		Maritimes	12	2	2	0.0							50.0	50.0								
	Ampicillin	British Columbia	47	≤ 1	> 32	27.7							70.2		2.1				27.7			
		Saskatchewan	64	≤ 1	4	9.4							84.4	4.7	1.6				9.4			
		Ontario	139	≤ 1	> 32	13.7							80.6	5.8					13.7			
		Québec	120	≤ 1	> 32	20.8							75.0	3.3	0.8				20.8			
		Maritimes	12	≤ 1	> 32	16.7							83.3						16.7			
	Cefoxitin	British Columbia	47	2	32	21.3							8.5	44.7	19.1	4.3	2.1	14.9	6.4			
		Saskatchewan	64	2	8	4.7							20.3	62.5	6.3	6.3		3.1	1.6			
		Ontario	139	2	16	8.6							18.0	59.7	9.4	2.2	2.2	3.6	5.0			
		Québec	120	2	32	14.2							20.8	51.7	11.7	0.8	0.8	9.2	5.0			
		Maritimes	12	2	32	16.7							50.0	33.3				8.3	8.3			
	Gentamicin	British Columbia	47	≤ 0.25	1	0.0					61.7	27.7	6.4		2.1	2.1						
		Saskatchewan	64	≤ 0.25	0.50	0.0					56.3	42.2	1.6									
		Ontario	139	≤ 0.25	0.50	0.7					62.6	36.0		0.7				0.7				
		Québec	120	≤ 0.25	0.50	1.7					66.7	30.0	1.7				0.8	0.8				
		Maritimes	12	0.50	0.50	8.3					16.7	75.0						8.3				
II	Kanamycin	British Columbia	47	≤ 8	≤ 8	0.0										100.0						
		Saskatchewan	64	≤ 8	≤ 8	3.1										96.9				3.1		
		Ontario	139	≤ 8	≤ 8	0.0										99.3	0.7					
		Québec	120	≤ 8	≤ 8	0.8										98.3	0.8			0.8		
		Maritimes	12	≤ 8	≤ 8	0.0										91.7	8.3					
	Nalidixic acid	British Columbia	47	4	4	0.0							2.1	27.7	66.0	4.3						
		Saskatchewan	64	4	4	0.0								29.7	67.2	3.1						
		Ontario	139	4	4	0.0							1.4	27.3	67.6	3.6						
		Québec	120	4	4	0.0							0.8	36.7	56.7	5.8						
		Maritimes	12	4	4	0.0								25.0	75.0							
	Streptomycin	British Columbia	47	≤ 32	> 64	29.8												70.2	19.1	10.6		
		Saskatchewan	64	≤ 32	> 64	35.9												64.1	14.1	21.9		
		Ontario	139	≤ 32	> 64	32.4												67.6	16.5	15.8		
		Québec	120	≤ 32	> 64	30.8												69.2	16.7	14.2		
		Maritimes	12	≤ 32	64	16.7												83.3	16.7			
	Trimethoprim-sulfamethoxazole	British Columbia	47	≤ 0.12	0.25	0.0				51.1	48.9											
		Saskatchewan	64	≤ 0.12	0.25	0.0				73.4	26.6											
		Ontario	139	≤ 0.12	0.25	0.7				75.5	23.7					0.7						
		Québec	120	≤ 0.12	0.25	0.0				69.2	30.8											
		Maritimes	12	≤ 0.12	≤ 0.12	0.0				100.0												
	Chloramphenicol	British Columbia	47	8	8	2.1								2.1	38.3	55.3	2.1		2.1			
		Saskatchewan	64	8	8	1.6								3.1	39.1	54.7	1.6		1.6			
		Ontario	139	4	8	0.7								6.5	48.2	43.9	0.7		0.7			
		Québec	120	4	8	0.0								2.5	48.3	45.8	3.3					
		Maritimes	12	8	8	0.0									50.0	50.0						
	Sulfisoxazole	British Columbia	47	32	64	6.4											19.1	48.9	23.4	2.1		6.4
		Saskatchewan	64	32	64	4.7											6.3	70.3	18.8			4.7
III		Ontario	139	32	64	2.2											20.1	64.7	12.2	0.7		2.2
		Québec	120	32	64	4.2											24.2	55.0	15.8	0.8		4.2
		Maritimes	12	32	64	8.3												83.3	8.3			8.3
	Tetracycline	British Columbia	47	≤ 4	> 32	29.8									70.2			4.3	25.5			
		Saskatchewan	64	≤ 4	> 32	35.9									64.1			4.7	31.3			
		Ontario	139	≤ 4	> 32	36.0									63.3	0.7		6.5	29.5			
		Québec	120	≤ 4	> 32	35.0									64.2	0.8		0.8	34.2			
		Maritimes	12	≤ 4	≤ 4	8.3									91.7				8.3			
IV																						

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.
The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

TABLE B.14. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from chickens; *Surveillance of Animal Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	209	≤ 1	> 32	15.8							78.9			2.9	2.4	2.4	13.4			
	Ceftiofur	209	1	> 8	16.3					0.5	17.7	64.6	0.5	0.5	0.5	15.8					
	Ceftriaxone	209	≤ 0.25	16	16.3					83.3			0.5	0.5	0.5	11.5	2.9		1.0		
	Ciprofloxacin	209	≤ 0.015	0.03	0.0	88.0	12.0														
II	Amikacin	209	1	2	0.0						7.2	63.6	27.8	1.4							
	Ampicillin	209	≤ 1	> 32	21.1							72.7	6.2					21.1			
	Cefoxitin	209	2	32	15.3							9.1	67.0	7.7	0.5	0.5	9.6	5.7			
	Gentamicin	209	≤ 0.25	0.50	2.4					58.9	36.4	1.9		0.5		0.5	1.9				
	Kanamycin	209	≤ 8	≤ 8	1.4										98.1	0.5			1.4		
	Nalidixic acid	209	4	4	0.0								27.3	72.2	0.5						
	Streptomycin	209	≤ 32	64	16.7												83.3	9.1	7.7		
	Trimethoprim-sulfamethoxazole	209	≤ 0.12	0.25	0.0				78.5	21.5											
III	Chloramphenicol	209	8	8	1.9									34.0	62.7	1.4		1.9			
	Sulfisoxazole	209	32	64	5.3											5.3	71.8	17.2	0.5		5.3
	Tetracycline	209	≤ 4	> 32	18.2									80.9	1.0		0.5	17.7			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.15. Distribution of minimal inhibitory concentrations for antimicrobials in *Escherichia coli* isolates from chickens; *Abattoir Surveillance*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	170	4	32	26.5							1.8	27.6	31.8	10.6	1.8	17.6	8.8			
	Ceftiofur	170	0.50	8	20.0				2.4	32.9	35.3	4.1	1.8	3.5	11.8	8.2					
	Ceftriaxone	170	≤ 0.25	16	22.9					70.6	2.4	3.5	0.6	1.8	8.8	8.8	3.5				
	Ciprofloxacin	170	≤ 0.015	≤ 0.015	0.0	94.1	2.4	0.6	2.4	0.6											
II	Amikacin	170	2	4	0.0						1.8	23.5	61.2	11.2	2.4						
	Ampicillin	170	4	> 32	36.5							14.1	32.9	15.3	0.6	0.6		36.5			
	Cefoxitin	170	4	> 32	25.9								14.1	45.3	12.4	2.4	7.6	18.2			
	Gentamicin	170	0.50	8	7.6					10.0	59.4	15.3	1.8	3.5	2.4	3.5	4.1				
	Kanamycin	170	≤ 8	> 64	20.0										79.4	0.6		0.6	19.4		
	Nalidixic acid	170	2	4	3.5						1.8	12.4	69.4	12.9			2.4	1.2			
	Streptomycin	170	≤ 32	> 64	43.5												56.5	17.6	25.9		
	Trimethoprim-sulfamethoxazole	170	≤ 0.12	> 4	11.8				51.8	26.5	7.6	1.2	1.2		11.8						
III	Chloramphenicol	170	4	8	2.9								4.1	47.1	45.3	0.6		2.9			
	Sulfisoxazole	170	≤ 16	> 256	40.0											54.7	4.7	0.6			40.0
	Tetracycline	170	32	> 32	50.6									48.8	0.6		4.1	46.5			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.16. Distribution of minimal inhibitory concentrations for antimicrobials in *Escherichia coli* isolates from chicken, by province/region; *Retail Meat Surveillance*, 2008.

	Antimicrobial	Province/region	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)															
				MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	Amoxicillin-clavulanic acid	British Columbia	70	32	> 32	52.9							1.4	12.9	24.3	7.1	1.4	40.0	12.9			
		Saskatchewan	91	4	32	20.9							9.9	18.7	31.9	14.3	4.4	14.3	6.6			
		Ontario	150	4	32	27.3							3.3	24.7	33.3	10.0	1.3	18.0	9.3			
		Québec	131	4	32	22.1							6.1	27.5	32.8	9.9	1.5	15.3	6.9			
		Maritimes	37	4	32	27.0							18.9	21.6	29.7	2.7		24.3	2.7			
	Ceftiofur	British Columbia	70	4	> 8	48.6				1.4	17.1	22.9	4.3		5.7	34.3	14.3					
		Saskatchewan	91	0.50	8	19.8				5.5	33.0	40.7			1.1	18.7	1.1					
		Ontario	150	0.50	> 8	24.0				1.3	29.3	41.3			4.0	12.0	12.0					
		Québec	131	0.50	8	18.3				3.8	33.6	37.4	3.1		3.8	10.7	7.6					
I		Maritimes	37	0.50	8	18.9					40.5	32.4		2.7	5.4	13.5	5.4					
	Ceftriaxone	British Columbia	70	4	16	54.3					41.4	1.4	2.9		5.7	18.6	28.6	1.4				
		Saskatchewan	91	≤ 0.25	8	20.9					79.1				1.1	13.2	6.6					
		Ontario	150	≤ 0.25	16	28.0					71.3	0.7			3.3	8.0	15.3	1.3				
		Québec	131	≤ 0.25	16	21.4					76.3	1.5		0.8	3.1	7.6	9.2	1.5				
		Maritimes	37	≤ 0.25	8	27.0					73.0				8.1	10.8	8.1					
	Ciprofloxacin	British Columbia	70	≤ 0.015	≤ 0.015	0.0	91.4	4.3			4.3											
		Saskatchewan	91	≤ 0.015	≤ 0.015	0.0	92.3	1.1		4.4	2.2											
		Ontario	150	≤ 0.015	≤ 0.015	0.0	95.3	0.7		0.7	3.3											
		Québec	131	≤ 0.015	≤ 0.015	0.8	90.1	0.8		0.8	6.1	1.5				0.8						
		Maritimes	37	≤ 0.015	≤ 0.015	0.0	100.0															
	Amikacin	British Columbia	70	2	4	0.0						2.9	12.9	74.3	10.0							
		Saskatchewan	91	2	4	0.0							27.5	57.1	14.3	1.1						
		Ontario	150	2	4	0.0						0.7	21.3	66.7	11.3							
		Québec	131	2	4	0.0						0.8	18.3	68.7	10.7	1.5						
		Maritimes	37	2	4	0.0							43.2	45.9	8.1	2.7						
	Ampicillin	British Columbia	70	> 32	> 32	62.9							2.9	28.6	5.7				62.9			
		Saskatchewan	91	4	> 32	40.7							17.6	28.6	12.1	1.1			40.7			
		Ontario	150	4	> 32	39.3							8.0	38.0	14.7				39.3			
		Québec	131	2	> 32	32.8							18.3	32.8	16.0				32.8			
		Maritimes	37	2	> 32	29.7							27.0	32.4	10.8			2.7	27.0			
	Cefoxitin	British Columbia	70	32	> 32	54.3								8.6	30.0	7.1		11.4	42.9			
		Saskatchewan	91	4	> 32	20.9							3.3	13.2	47.3	13.2	2.2	4.4	16.5			
		Ontario	150	4	> 32	28.0								13.3	47.3	10.7	0.7	4.7	23.3			
		Québec	131	4	> 32	19.8								16.0	52.7	9.2	2.3	3.8	16.0			
		Maritimes	37	4	> 32	24.3							5.4	18.9	35.1	10.8	5.4	5.4	18.9			
	Gentamicin	British Columbia	70	0.50	1	5.7					7.1	71.4	15.7					5.7				
		Saskatchewan	91	0.50	2	7.7					16.5	57.1	15.4	2.2		1.1	2.2	5.5				
		Ontario	150	0.50	16	12.0					9.3	64.7	12.0			2.0	3.3	8.7				
		Québec	131	0.50	> 16	20.6					5.3	61.8	11.5			0.8	9.2	11.5				
		Maritimes	37	0.50	1	5.4					29.7	51.4	13.5				2.7	2.7				
II	Kanamycin	British Columbia	70	≤ 8	16	7.1										90.0	2.9			7.1		
		Saskatchewan	91	≤ 8	> 64	12.1										84.6	3.3		1.1	11.0		
		Ontario	150	≤ 8	16	9.3										88.7	2.0		0.7	8.7		
		Québec	131	≤ 8	16	6.1										89.3	4.6			6.1		
		Maritimes	37	≤ 8	16	8.1										89.2	2.7			8.1		
	Nalidixic acid	British Columbia	70	2	4	4.3						1.4	14.3	67.1	11.4	1.4			4.3			
		Saskatchewan	91	2	4	6.6						2.2	13.2	70.3	7.7			2.2	4.4			
		Ontario	150	2	4	4.0							10.0	78.7	7.3				4.0			
		Québec	131	2	4	8.4						1.5	15.3	68.7	5.3	0.8		1.5	6.9			
		Maritimes	37	2	2	0.0						2.7	21.6	70.3	5.4							
	Streptomycin	British Columbia	70	≤ 32	> 64	31.4												68.6	10.0	21.4		
		Saskatchewan	91	≤ 32	> 64	28.6												71.4	14.3	14.3		
		Ontario	150	≤ 32	> 64	33.3												66.7	10.7	22.7		
		Québec	131	≤ 32	> 64	38.9												61.1	14.5	24.4		
		Maritimes	37	≤ 32	> 64	29.7												70.3	8.1	21.6		
	Trimethoprim-sulfamethoxazole	British Columbia	70	≤ 0.12	0.50	5.7				58.6	30.0	2.9	1.4	1.4		5.7						
		Saskatchewan	91	≤ 0.12	0.25	3.3				67.0	23.1	5.5	1.1			3.3						
		Ontario	150	≤ 0.12	0.50	6.7				53.3	31.3	6.7	1.3	0.7		6.7						
		Québec	131	0.25	> 4	15.3				44.3	30.5	6.1	3.8		0.8	14.5						
		Maritimes	37	0.25	> 4	16.2				35.1	45.9	2.7			2.7	13.5						
	Chloramphenicol	British Columbia	70	8	16	5.7								1.4	40.0	48.6	4.3		5.7			
		Saskatchewan	91	4	8	3.3								1.1	56.0	37.4	2.2		3.3			
		Ontario	150	4	8	4.7								4.7	50.0	40.0	0.7		4.7			
		Québec	131	4	8	4.6								4.6	51.1	36.6	3.1		4.6			
		Maritimes	37	4	8	8.1								2.7	64.9	24.3			8.1			
	Sulfisoxazole	British Columbia	70	≤ 16	> 256	27.1											65.7	5.7		1.4		27.1
		Saskatchewan	91	≤ 16	> 256	19.8											72.5	5.5	2.2			19.8
III		Ontario	150	≤ 16	> 256	30.7											61.3	8.0				30.7
		Québec	131	≤ 16	> 256	45.0											50.4	4.6				45.0
		Maritimes	37	≤ 16	> 256	29.7											59.5	8.1	2.7			29.7
	Tetracycline	British Columbia	70	≤ 4	> 32	45.7									54.3			1.4	44.3			
		Saskatchewan	91	≤ 4	> 32	48.4									50.5	1.1		5.5	42.9			
		Ontario	150	≤ 4	> 32	40.0									58.7	1.3	1.3	4.7	34.0			
		Québec	131	≤ 4	> 32	45.0									54.2	0.8	1.5	5.3	38.2			
		Maritimes	37	≤ 4	> 32	40.5									59.5		2.7	10.8	27.0			
IV																						

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.
The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

TABLE B.17. Distribution of minimal inhibitory concentrations for antimicrobials in *Campylobacter* isolates from chicken, by *Campylobacter* species and province; *Retail Meat Surveillance*, 2008.

Antimicrobial	Species	Province/region	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)											
				MIC 50	MIC 90		≤ 0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	> 64
Ciprofloxacin	*Campylobacter coli*	British Columbia	6	0.125	16	16.7			16.7	50.0	16.7						16.7			
Ciprofloxacin	*Campylobacter coli*	Saskatchewan	3	0.125	0.125	0.0				100.0										
Ciprofloxacin	*Campylobacter coli*	Ontario	16	0.125	0.25	6.3			12.5	43.8	37.5						6.3			
Ciprofloxacin	*Campylobacter coli*	Québec	5	0.125	0.25	0.0			40.0	20.0	40.0									
Ciprofloxacin	*Campylobacter jejuni*	British Columbia	44	0.125	0.25	6.8			43.2	31.8	18.2					4.5	2.3			
Ciprofloxacin	*Campylobacter jejuni*	Saskatchewan	37	0.125	8	10.8			43.2	35.1	10.8					10.8				
Ciprofloxacin	*Campylobacter jejuni*	Ontario	104	0.064	0.25	3.8			53.8	32.7	9.6					2.9		1.0		
Ciprofloxacin	*Campylobacter jejuni*	Québec	49	0.064	0.25	0.0			65.3	20.4	14.3									
Ciprofloxacin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
Ciprofloxacin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
Ciprofloxacin	*Campylobacter* spp.	Ontario	0	0	0	0.0														
Ciprofloxacin	*Campylobacter* spp.	Québec	0	0	0	0.0														
Telithromycin	*Campylobacter coli*	British Columbia	6	0.5	2	0.0					50.0	33.3		16.7						
Telithromycin	*Campylobacter coli*	Saskatchewan	3	0.25	1	0.0					66.7		33.3							
Telithromycin	*Campylobacter coli*	Ontario	16	4	16	12.5					18.8	6.3	6.3	12.5	43.8		12.5			
Telithromycin	*Campylobacter coli*	Québec	5	0.5	1	0.0						60.0	40.0							
Telithromycin	*Campylobacter jejuni*	British Columbia	44	0.5	1	0.0				2.3	13.6	45.5	34.1	4.5						
Telithromycin	*Campylobacter jejuni*	Saskatchewan	37	0.5	1	0.0				5.4	18.9	45.9	24.3	5.4						
Telithromycin	*Campylobacter jejuni*	Ontario	104	0.5	2	2.9					9.6	48.1	28.8	4.8	1.0	4.8	2.9			
Telithromycin	*Campylobacter jejuni*	Québec	49	0.5	8	2.0					8.2	57.1	18.4	4.1	2.0	8.2	2.0			
Telithromycin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
Telithromycin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
Telithromycin	*Campylobacter* spp.	Ontario	0	0	0	0.0														
Telithromycin	*Campylobacter* spp.	Québec	0	0	0	0.0														
Azithromycin	*Campylobacter coli*	British Columbia	6	0.064	0.125	0.0		50.0	33.3	16.7										
Azithromycin	*Campylobacter coli*	Saskatchewan	3	0.064	0.064	0.0		33.3	66.7											
Azithromycin	*Campylobacter coli*	Ontario	16	0.125	> 64	18.8		12.5	31.3	12.5	25.0									18.8
Azithromycin	*Campylobacter coli*	Québec	5	0.032	0.064	0.0		80.0	20.0											
Azithromycin	*Campylobacter jejuni*	British Columbia	44	0.064	0.064	0.0	6.8	34.1	50.0	6.8	2.3									
Azithromycin	*Campylobacter jejuni*	Saskatchewan	37	0.032	0.064	0.0	27.0	32.4	35.1	5.4										
Azithromycin	*Campylobacter jejuni*	Ontario	104	0.064	0.125	6.7	1.9	34.6	48.1	7.7		1.0								6.7
Azithromycin	*Campylobacter jejuni*	Québec	49	0.064	> 64	12.2	4.1	30.6	51.0	2.0										12.2
Azithromycin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
Azithromycin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
Azithromycin	*Campylobacter* spp.	Ontario	0	0	0	0.0														
Azithromycin	*Campylobacter* spp.	Québec	0	0	0	0.0														
Clindamycin	*Campylobacter coli*	British Columbia	6	0.25	0.5	0.0				33.3	50.0	16.7								
Clindamycin	*Campylobacter coli*	Saskatchewan	3	0.125	0.25	0.0				66.7	33.3									
Clindamycin	*Campylobacter coli*	Ontario	16	0.25	16	12.5				18.8	43.8	6.3	18.8				12.5			
Clindamycin	*Campylobacter coli*	Québec	5	0.064	0.25	0.0			60.0	20.0	20.0									
Clindamycin	*Campylobacter jejuni*	British Columbia	44	0.125	0.25	0.0			22.7	47.7	27.3			2.3						
Clindamycin	*Campylobacter jejuni*	Saskatchewan	37	0.125	0.25	0.0		5.4	32.4	43.2	13.5	5.4								
Clindamycin	*Campylobacter jejuni*	Ontario	104	0.125	0.5	2.9			10.6	59.6	17.3	5.8		1.0	2.9			2.9		
Clindamycin	*Campylobacter jejuni*	Québec	49	0.125	4	2.0			14.3	55.1	18.4			2.0	8.2	2.0				
Clindamycin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
Clindamycin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
Clindamycin	*Campylobacter* spp.	Ontario	0	0	0	0.0														
Clindamycin	*Campylobacter* spp.	Québec	0	0	0	0.0														
Erythromycin	*Campylobacter coli*	British Columbia	6	0.25	0.5	0.0					66.7	33.3								
Erythromycin	*Campylobacter coli*	Saskatchewan	3	0.25	0.5	0.0					66.7	33.3								
Erythromycin	*Campylobacter coli*	Ontario	16	2	> 64	18.8					12.5	18.8	12.5	31.3	6.3			6.3		12.5
Erythromycin	*Campylobacter coli*	Québec	5	0.25	0.5	0.0				20.0	40.0	40.0								
Erythromycin	*Campylobacter jejuni*	British Columbia	44	0.25	1	0.0			4.5	9.1	45.5	29.5	9.1	2.3						
Erythromycin	*Campylobacter jejuni*	Saskatchewan	37	0.25	0.5	0.0			2.7	21.6	51.4	24.3								
Erythromycin	*Campylobacter jejuni*	Ontario	104	0.25	1	6.7				5.8	54.8	23.1	6.7	1.9	1.0					6.7
Erythromycin	*Campylobacter jejuni*	Québec	49	0.5	> 64	12.2				10.2	36.7	38.8	2.0						2.0	10.2
Erythromycin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
Erythromycin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
Erythromycin	*Campylobacter* spp.	Ontario	0	0	0	0.0														
Erythromycin	*Campylobacter* spp.	Québec	0	0	0	0.0														

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.17 (continued). Distribution of minimal inhibitory concentrations for antimicrobials in *Campylobacter* isolates from chicken, by *Campylobacter* species and province; *Retail Meat Surveillance*, 2008.

	Antimicrobial	Species	Province/region	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)												
					MIC 50	MIC 90		≤ 0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	> 64
	Gentamicin	*Campylobacter coli*	British Columbia	6	0.5	1	0.0					33.3	33.3	33.3							
	Gentamicin	*Campylobacter coli*	Saskatchewan	3	1	1	0.0							100.0							
	Gentamicin	*Campylobacter coli*	Ontario	16	0.5	2	6.3						62.5	25.0	6.3					6.3	
	Gentamicin	*Campylobacter coli*	Québec	5	0.5	0.5	0.0						100.0								
	Gentamicin	*Campylobacter jejuni*	British Columbia	44	0.5	1	0.0					4.5	75.0	20.5							
	Gentamicin	*Campylobacter jejuni*	Saskatchewan	37	0.5	1	0.0					2.7	67.6	29.7							
	Gentamicin	*Campylobacter jejuni*	Ontario	104	0.5	1	0.0					1.9	67.3	30.8							
	Gentamicin	*Campylobacter jejuni*	Québec	49	0.5	1	0.0					2.0	87.8	10.2							
	Gentamicin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Gentamicin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Gentamicin	*Campylobacter* spp.	Ontario	0	0	0	0.0														
II	Gentamicin	*Campylobacter* spp.	Québec	0	0	0	0.0														
	Nalidixic acid	*Campylobacter coli*	British Columbia	6	8	> 64	16.7									33.3	50.0				16.7
	Nalidixic acid	*Campylobacter coli*	Saskatchewan	3	≤ 4	≤ 4	0.0									100.0					
	Nalidixic acid	*Campylobacter coli*	Ontario	16	8	16	6.3									43.8	43.8	6.3			6.3
	Nalidixic acid	*Campylobacter coli*	Québec	5	≤ 4	8	0.0									80.0	20.0				
	Nalidixic acid	*Campylobacter jejuni*	British Columbia	44	≤ 4	8	6.8									70.5	20.5	2.3			6.8
	Nalidixic acid	*Campylobacter jejuni*	Saskatchewan	37	≤ 4	> 64	10.8									78.4	10.8				10.8
	Nalidixic acid	*Campylobacter jejuni*	Ontario	104	≤ 4	8	3.8									88.5	7.7				3.8
	Nalidixic acid	*Campylobacter jejuni*	Québec	49	≤ 4	8	0.0									81.6	18.4				
	Nalidixic acid	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Nalidixic acid	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Nalidixic acid	*Campylobacter* spp.	Ontario	0	0	0	0.0														
	Nalidixic acid	*Campylobacter* spp.	Québec	0	0	0	0.0														
	Florfenicol	*Campylobacter coli*	British Columbia	6	1	1	0.0							100.0							
	Florfenicol	*Campylobacter coli*	Saskatchewan	3	1	1	0.0							100.0							
	Florfenicol	*Campylobacter coli*	Ontario	16	1	2	0.0							68.8	31.3						
	Florfenicol	*Campylobacter coli*	Québec	5	1	1	0.0						20.0	80.0							
	Florfenicol	*Campylobacter jejuni*	British Columbia	44	1	2	0.0						4.5	84.1	11.4						
	Florfenicol	*Campylobacter jejuni*	Saskatchewan	37	1	1	0.0						27.0	70.3	2.7						
	Florfenicol	*Campylobacter jejuni*	Ontario	104	1	1	0.0						15.4	79.8	3.8	1.0					
	Florfenicol	*Campylobacter jejuni*	Québec	49	1	1	0.0						12.2	83.7	4.1						
	Florfenicol	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Florfenicol	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Florfenicol	*Campylobacter* spp.	Ontario	0	0	0	0.0														
III	Florfenicol	*Campylobacter* spp.	Québec	0	0	0	0.0														
	Tetracycline	*Campylobacter coli*	British Columbia	6	8	> 64	33.3					33.3		16.7			16.7			16.7	16.7
	Tetracycline	*Campylobacter coli*	Saskatchewan	3	0.25	0.25	0.0				33.3	66.7									
	Tetracycline	*Campylobacter coli*	Ontario	16	1	> 64	43.8				12.5	12.5	18.8	12.5					6.3		37.5
	Tetracycline	*Campylobacter coli*	Québec	5	0.5	64	20.0						80.0							20.0	
	Tetracycline	*Campylobacter jejuni*	British Columbia	44	0.25	> 64	31.8			2.3	25.0	25.0	9.1		2.3	2.3	2.3		2.3	11.4	18.2
	Tetracycline	*Campylobacter jejuni*	Saskatchewan	37	8	> 64	48.6				16.2	32.4					2.7		24.3	5.4	18.9
	Tetracycline	*Campylobacter jejuni*	Ontario	104	32	> 64	50.0			1.9	23.1	18.3	6.7						4.8	18.3	26.9
	Tetracycline	*Campylobacter jejuni*	Québec	49	64	> 64	59.2				24.5	12.2	2.0	2.0					2.0	32.7	24.5
	Tetracycline	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Tetracycline	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Tetracycline	*Campylobacter* spp.	Ontario	0	0	0	0.0														
	Tetracycline	*Campylobacter* spp.	Québec	0	0	0	0.0														
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.
Campylobacter spp. include unidentified species, some of which may be intrinsically resistant to nalidixic acid.

TABLE B.18. Distribution of minimal inhibitory concentrations for antimicrobials in *Enterococcus* isolates from chicken, by *Enterococcus* species and province; *Retail Meat Surveillance*, 2008.

Antimicrobial	Species	Prov./ region	n	Percentile		% R	Distribution (%) of MICs (µg/mL)																		
				MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1,024	2,048	> 2,048
Ciprofloxacin	*Enterococcus faecalis*	BC	70	1	2	0.0						4.3	74.3	21.4											
		SA	85	1	2	1.2						1.2	80.0	17.6	1.2										
		ON	148	1	2	1.4						2.7	75.0	20.9	0.7	0.7									
		QC	133	1	2	0.0						1.5	80.5	18.0											
	Enterococcus faecium	BC	3	1	2	0.0						33.3	33.3	33.3											
		SA	1	2	2	0.0								100.0											
		ON	3	4	4	66.7								33.3	66.7										
		QC	5	1	> 4	20.0							60.0	20.0		20.0									
	Enterococcus spp.	BC	4	1	1	0.0						25.0	75.0												
		SA	5	0.25	2	0.0					60.0		20.0	20.0											
		ON	3	0.5	2	0.0					33.3	33.3		33.3											
		QC	4	0.5	1	0.0					50.0	25.0	25.0												
Daptomycin	*Enterococcus faecalis*	BC	70	1	1	0.0						25.7	71.4	2.9											
		SA	85	1	1	0.0						24.7	74.1	1.2											
		ON	148	1	1	0.0						36.5	62.2	1.4											
		QC	133	1	1	0.0						27.8	70.7	1.5											
	Enterococcus faecium	BC	3	2	2	0.0								100.0											
		SA	1	4	4	0.0									100.0										
		ON	3	2	4	0.0								66.7	33.3										
		QC	5	2	4	0.0							20.0	60.0	20.0										
	Enterococcus spp.	BC	4	2	2	0.0						25.0		75.0											
		SA	5	2	4	0.0						20.0		60.0	20.0										
		ON	3	≤ 0.5	≤ 0.5	0.0						100.0													
		QC	4	1	2	0.0						50.0	25.0	25.0											
Linezolid	*Enterococcus faecalis*	BC	70	2	2	0.0							21.4	78.6											
		SA	85	2	2	0.0							29.4	70.6											
		ON	148	2	2	0.0							16.2	83.8											
		QC	133	2	2	0.0							22.6	77.4											
	Enterococcus faecium	BC	3	2	2	0.0							33.3	66.7											
I		SA	1	1	1	0.0							100.0												
		ON	3	1	2	0.0							66.7	33.3											
		QC	5	2	2	0.0							40.0	60.0											
	Enterococcus spp.	BC	4	2	2	0.0							25.0	75.0											
		SA	5	2	2	0.0							20.0	80.0											
		ON	3	2	2	0.0						33.3		66.7											
		QC	4	1	1	0.0							100.0												
Tigecycline	*Enterococcus faecalis*	BC	70	0.12	0.25	0.0			14.3	58.6	27.1														
		SA	85	0.12	0.25	0.0			4.7	57.6	36.5	1.2													
		ON	148	0.12	0.25	0.0			5.4	62.2	31.1	1.4													
		QC	133	0.12	0.25	0.8			6.8	55.6	35.3	1.5	0.8												
	Enterococcus faecium	BC	3	0.12	0.12	0.0			33.3	66.7															
		SA	1	0.12	0.12	0.0				100.0															
		ON	3	0.12	0.12	0.0			33.3	66.7															
		QC	5	0.12	0.5	0.0			20.0	40.0	20.0	20.0													
	Enterococcus spp.	BC	4	0.12	0.12	0.0			25.0	75.0															
		SA	5	0.25	0.5	0.0			20.0	20.0	20.0	40.0													
		ON	3	0.12	0.12	0.0				100.0															
		QC	4	0.12	0.12	0.0			50.0	50.0															
Vancomycin	*Enterococcus faecalis*	BC	70	1	2	0.0							65.7	34.3											
		SA	85	1	2	0.0							61.2	38.8											
		ON	148	1	2	0.0						0.7	62.8	35.1	1.4										
		QC	133	1	2	0.0						0.8	57.9	40.6	0.8										
	Enterococcus faecium	BC	3	≤ 0.5	1	0.0						66.7	33.3												
		SA	1	≤ 0.5	≤ 0.5	0.0						100.0													
		ON	3	≤ 0.5	≤ 0.5	0.0						100.0													
		QC	5	≤ 0.5	2	0.0						80.0		20.0											
	Enterococcus spp.	BC	4	1	8	0.0						50.0	25.0			25.0									
		SA	5	1	1	0.0						40.0	60.0												
		ON	3	1	4	0.0						33.3	33.3		33.3										
		QC	4	1	2	0.0						50.0	25.0	25.0											
Erythromycin	*Enterococcus faecalis*	BC	70	> 8	> 8	54.3						18.6	12.9	14.3			54.3								
		SA	85	> 8	> 8	69.4						20.0	5.9	4.7			69.4								
		ON	148	4	> 8	49.3						31.1	12.2	6.8	0.7	2.0	47.3								
		QC	133	> 8	> 8	54.9						29.3	12.0	3.8			54.9								
	Enterococcus faecium	BC	3	2	> 8	33.3						33.3		33.3			33.3								
		SA	1	> 8	> 8	100.0											100.0								
		ON	3	> 8	> 8	100.0											100.0								
		QC	5	> 8	> 8	80.0									20.0		80.0								
	Enterococcus spp.	BC	4	1	4	0.0						50.0	25.0		25.0										
		SA	5	2	> 8	20.0						40.0		20.0	20.0		20.0								
		ON	3	≤ 0.5	> 8	33.3						66.7					33.3								
		QC	4	> 8	> 8	100.0											100.0								
Gentamicin	*Enterococcus faecalis*	BC	70	≤ 128	≤ 128	4.3														95.7		2.9	1.4		
		SA	85	≤ 128	≤ 128	3.5														96.5				3.5	
		ON	148	≤ 128	≤ 128	4.7														95.3		0.7	0.7	3.4	
		QC	133	≤ 128	512	10.5														87.2	2.3	6.8		3.8	
	Enterococcus faecium	BC	3	≤ 128	≤ 128	0.0														100.0					
II		SA	1	≤ 128	≤ 128	0.0														100.0					
		ON	3	≤ 128	≤ 128	0.0														100.0					
		QC	5	≤ 128	≤ 128	0.0														100.0					
	Enterococcus spp.	BC	4	≤ 128	≤ 128	0.0														100.0					
		SA	5	≤ 128	≤ 128	0.0														100.0					
		ON	3	≤ 128	≤ 128	0.0														100.0					
		QC	4	≤ 128	≤ 128	0.0														100.0					
Kanamycin	*Enterococcus faecalis*	BC	70	≤ 128	> 1,024	20.0														78.6		1.4	2.9	17.1	
		SA	85	≤ 128	> 1,024	24.7														74.1		1.2	2.4	22.4	
		ON	148	≤ 128	> 1,024	15.5														83.8		0.7		15.5	
		QC	133	≤ 128	> 1,024	21.8														77.4		0.8	0.8	21.1	
	Enterococcus faecium	BC	3	256	> 1,024	33.3															66.7			33.3	
		SA	1	256	256	0.0															100.0				
		ON	3	256	256	0.0														33.3	66.7				
		QC	5	≤ 128	256	0.0														60.0	40.0				
	Enterococcus spp.	BC	4	≤ 128	≤ 128	0.0														100.0					
		SA	5	≤ 128	256	0.0														80.0	20.0				
		ON	3	≤ 128	≤ 128	0.0														100.0					
		QC	4	≤ 128	≤ 128	0.0														100.0					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.18 (continued). Distribution of minimal inhibitory concentrations for antimicrobials in *Enterococcus* isolates from chicken, by *Enterococcus* species and province; *Retail Meat Surveillance*, 2008.

	Antimicrobial	Species	Prov./ region	n	Percentile		% R	Distribution (%) of MICs (µg/mL)																		
					MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1,024	2,048	> 2,048
	Lincomycin[a]	*Enterococcus faecium*	BC	3	> 32	> 32	100.0											33.3		66.7						
			SA	1	> 32	> 32	100.0													100.0						
			ON	3	> 32	> 32	100.0													100.0						
			QC	5	> 32	> 32	100.0										20.0			80.0						
		Enterococcus spp.	BC	4	> 32	> 32	100.0												50.0	50.0						
			SA	5	> 32	> 32	100.0											20.0		80.0						
			ON	3	16	> 32	100.0											66.7		33.3						
			QC	4	> 32	> 32	100.0													100.0						
	Penicillin	*Enterococcus faecalis*	BC	70	4	4	0.0								28.6	71.4										
			SA	85	4	4	0.0								40.0	60.0										
			ON	148	4	4	0.0								33.8	66.2										
			QC	133	4	4	0.0								24.1	75.9										
		Enterococcus faecium	BC	3	2	> 16	33.3								66.7				33.3							
			SA	1	16	16	100.0											100.0								
			ON	3	16	16	66.7										33.3	66.7								
			QC	5	8	16	40.0						20.0		20.0		20.0	40.0								
		Enterococcus spp.	BC	4	4	> 16	25.0							25.0	25.0	25.0			25.0							
			SA	5	2	16	20.0						20.0	20.0	20.0	20.0		20.0								
			ON	3	≤ 0.5	1	0.0						66.7	33.3												
			QC	4	1	2	0.0						50.0	25.0	25.0											
II	Quinupristin-dalfopristin[a]	*Enterococcus faecium*	BC	3	2	8	33.3							33.3	33.3		33.3									
			SA	1	16	16	100.0											100.0								
			ON	3	16	16	100.0									33.3		66.7								
			QC	5	16	32	80.0								20.0			40.0	40.0							
		Enterococcus spp.	BC	4	8	8	50.0							25.0	25.0		50.0									
			SA	5	8	8	80.0								20.0		80.0									
			ON	3	2	2	0.0								100.0											
			QC	4	16	16	100.0									25.0	25.0	50.0								
	Streptomycin	*Enterococcus faecalis*	BC	70	≤ 512	> 2,048	41.4																58.6	1.4	5.7	34.3
			SA	85	≤ 512	> 2,048	40.0																60.0		5.9	34.1
			ON	148	≤ 512	> 2,048	28.4																71.6	2.7	4.7	20.9
			QC	133	≤ 512	> 2,048	39.1																60.9	3.8	9.0	26.3
		Enterococcus faecium	BC	3	≤ 512	> 2,048	33.3																66.7			33.3
			SA	1	1,024	1,024	100.0																	100.0		
			ON	3	≤ 512	≤ 512	0.0																100.0			
			QC	5	≤ 512	≤ 512	0.0																100.0			
		Enterococcus spp.	BC	4	≤ 512	≤ 512	0.0																100.0			
			SA	5	≤ 512	2,048	20.0																80.0		20.0	
			ON	3	≤ 512	≤ 512	0.0																100.0			
			QC	4	≤ 512	1,024	25.0																75.0	25.0		
	Tylosin	*Enterococcus faecalis*	BC	70	> 32	> 32	52.9							10.0	35.7			1.4		52.9						
			SA	85	> 32	> 32	69.4							5.9	24.7					69.4						
			ON	148	> 32	> 32	50.0						0.7	5.4	43.2	0.7				50.0						
			QC	133	> 32	> 32	54.1							6.0	38.3	0.8	0.8			54.1						
		Enterococcus faecium	BC	3	4	> 32	33.3									66.7				33.3						
			SA	1	> 32	> 32	100.0													100.0						
			ON	3	> 32	> 32	100.0													100.0						
			QC	5	> 32	> 32	80.0									20.0				80.0						
		Enterococcus spp.	BC	4	1	2	0.0							75.0	25.0											
			SA	5	2	> 32	20.0							20.0	60.0					20.0						
			ON	3	2	> 32	33.3							33.3	33.3					33.3						
			QC	4	> 32	> 32	100.0													100.0						
III	Chloramphenicol	*Enterococcus faecalis*	BC	70	8	8	0.0									21.4	78.6									
			SA	85	8	8	0.0									10.6	88.2	1.2								
			ON	148	8	8	0.7									16.9	81.1	1.4	0.7							
			QC	133	8	8	6.0									21.1	72.9		0.8	5.3						
		Enterococcus faecium	BC	3	4	4	0.0									100.0										
			SA	1	4	4	0.0									100.0										
			ON	3	4	8	0.0									66.7	33.3									
			QC	5	4	8	0.0									80.0	20.0									
		Enterococcus spp.	BC	4	4	8	0.0								25.0	50.0	25.0									
			SA	5	4	4	0.0									100.0										
			ON	3	4	4	0.0									100.0										
			QC	4	8	8	0.0									50.0	50.0									
	Nitrofurantoin	*Enterococcus faecalis*	BC	70	8	16	0.0										55.7	41.4	2.9							
			SA	85	8	16	0.0										55.3	42.4		2.4						
			ON	148	8	16	0.0										56.1	35.8	4.1	4.1						
			QC	133	8	16	0.0										60.9	32.3	3.8	3.0						
		Enterococcus faecium	BC	3	64	> 64	33.3													66.7	33.3					
			SA	1	> 64	> 64	100.0														100.0					
			ON	3	> 64	> 64	66.7													33.3	66.7					
			QC	5	64	> 64	20.0												20.0	60.0	20.0					
		Enterococcus spp.	BC	4	> 64	> 64	50.0										25.0	25.0			50.0					
			SA	5	> 64	> 64	60.0												20.0	20.0	60.0					
			ON	3	16	32	0.0										33.3	33.3	33.3							
			QC	4	> 64	> 64	75.0												25.0		75.0					
	Tetracycline	*Enterococcus faecalis*	BC	70	> 32	> 32	75.7									22.9	1.4		8.6	67.1						
			SA	85	> 32	> 32	85.9									14.1			7.1	78.8						
			ON	148	> 32	> 32	89.2									10.8		0.7	8.8	79.7						
			QC	133	> 32	> 32	86.5									13.5		0.8	6.8	78.9						
		Enterococcus faecium	BC	3	32	> 32	66.7									33.3			33.3	33.3						
			SA	1	> 32	> 32	100.0													100.0						
			ON	3	> 32	> 32	100.0													100.0						
			QC	5	> 32	> 32	80.0									20.0			20.0	60.0						
		Enterococcus spp.	BC	4	32	> 32	75.0									25.0			50.0	25.0						
			SA	5	> 32	> 32	80.0									20.0			20.0	60.0						
			ON	3	≤ 4	≤ 4	0.0									100.0										
			QC	4	> 32	> 32	100.0												50.0	50.0						
IV	Flavomycin	*Enterococcus faecalis*	BC	70	≤ 1	≤ 1	0.0							100.0												
			SA	85	≤ 1	≤ 1	0.0							100.0												
			ON	148	≤ 1	≤ 1	0.7							96.6	2.0		0.7		0.7							
			QC	133	≤ 1	≤ 1	0.8							95.5	3.0	0.8			0.8							
		Enterococcus faecium	BC	3	16	> 16	33.3								33.3			33.3	33.3							
			SA	1	2	2	0.0								100.0											
			ON	3	4	8	0.0								33.3	33.3	33.3									
			QC	5	16	> 16	40.0									40.0		20.0	40.0							
		Enterococcus spp.	BC	4	> 16	> 16	50.0							25.0			25.0		50.0							
			SA	5	4	> 16	40.0								20.0	40.0			40.0							
			ON	3	8	> 16	33.3								33.3		33.3		33.3							
			QC	4	> 16	> 16	50.0							50.0					50.0							

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

[a] Resistance to quinupristin-dalfopristin and lincomycin is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

TABLE B.19. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from pigs; *Farm Surveillance*, 2008.

	Antimicrobial	n	Percentiles MIC 50	Percentiles MIC 90	% R	Distribution (%) of MICs (µg/mL) ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	61	≤ 1	8	0.0							62.3	6.6		23.0	8.2					
	Ceftiofur	61	1	1	0.0						27.9	68.9	3.3								
	Ceftriaxone	61	≤ 0.25	≤ 0.25	0.0					100.0											
	Ciprofloxacin	61	≤ 0.015	≤ 0.015	0.0	90.2	8.2	1.6													
II	Amikacin	61	1	2	0.0							50.8	44.3	4.9							
	Ampicillin	61	≤ 1	> 32	32.8							60.7	3.3	3.3			1.6	31.1			
	Cefoxitin	61	2	4	0.0							4.9	49.2	42.6	3.3						
	Gentamicin	61	0.50	1	1.6					37.7	47.5	11.5	1.6				1.6				
	Kanamycin	61	≤ 8	> 64	21.3										78.7				21.3		
	Nalidixic acid	61	4	4	0.0								36.1	60.7	3.3						
	Streptomycin	61	≤ 32	> 64	36.1												63.9	9.8	26.2		
	Trimethoprim-sulfamethoxazole	61	≤ 0.12	0.25	3.3				55.7	39.3	1.6				3.3						
III	Chloramphenicol	61	8	> 32	24.6									23.0	50.8	1.6	1.6	23.0			
	Sulfisoxazole	61	64	> 256	39.3											6.6	27.9	24.6	1.6		39.3
	Tetracycline	61	32	> 32	57.4									42.6			18.0	39.3			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.20. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2008.

	Antimicrobial	n	Percentiles MIC 50	Percentiles MIC 90	% R	Distribution (%) of MICs (µg/mL) ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	151	≤ 1	16	1.3							66.9	5.3	2.0	13.2	11.3	1.3				
	Ceftiofur	151	1	1	0.7					0.7	17.9	74.8	6.0			0.7					
	Ceftriaxone	151	≤ 0.25	≤ 0.25	0.7					99.3						0.7					
	Ciprofloxacin	151	≤ 0.015	0.03	0.0	76.2	21.2	2.6													
II	Amikacin	151	1	2	0.0						2.0	49.0	45.7	3.3							
	Ampicillin	151	≤ 1	> 32	27.8							57.0	12.6	2.0	0.7			27.8			
	Cefoxitin	151	2	8	0.7							6.6	48.3	34.4	8.6	1.3		0.7			
	Gentamicin	151	0.50	1	0.7					35.8	52.3	10.6	0.7				0.7				
	Kanamycin	151	≤ 8	16	9.9										89.4	0.7			9.9		
	Nalidixic acid	151	4	4	0.0								18.5	75.5	6.0						
	Streptomycin	151	≤ 32	> 64	44.4												55.6	10.6	33.8		
	Trimethoprim-sulfamethoxazole	151	≤ 0.12	0.50	6.6				52.3	30.5	7.9	1.3	1.3	0.7	6.0						
III	Chloramphenicol	151	8	> 32	23.2									15.2	56.3	5.3		23.2			
	Sulfisoxazole	151	64	> 256	46.4											7.9	28.5	17.2			46.4
	Tetracycline	151	32	> 32	57.6									42.4		1.3	17.9	38.4			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.21. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from pork; *Retail Meat Surveillance*, 2003-2008.

	Antimicrobial	Province/region	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
				MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	Amoxicillin-clavulanic acid	British Columbia	4	≤ 1	≤ 1	0.0							100.0									
		Saskatchewan	7	≤ 1	2	0.0							85.7	14.3								
		Ontario	14	2	16	0.0							42.9	14.3	7.1	21.4	14.3					
		Québec	9	≤ 1	> 32	11.1							55.6			22.2	11.1		11.1			
		Maritimes	2	≤ 1	≤ 1	0.0							100.0									
	Ceftiofur	British Columbia	4	1	1	0.0						50.0	50.0									
		Saskatchewan	7	1	1	0.0						28.6	71.4									
		Ontario	14	1	1	0.0						21.4	71.4	7.1								
		Québec	9	1	> 8	11.1						22.2	66.7				11.1					
I		Maritimes	2	1	1	0.0						50.0	50.0									
	Ceftriaxone	British Columbia	4	≤ 0.25	≤ 0.25	0.0					100.0											
		Saskatchewan	7	≤ 0.25	≤ 0.25	0.0					100.0											
		Ontario	14	≤ 0.25	≤ 0.25	0.0					100.0											
		Québec	9	≤ 0.25	8	11.1					88.9					11.1						
		Maritimes	2	≤ 0.25	≤ 0.25	0.0					100.0											
	Ciprofloxacin	British Columbia	4	≤ 0.015	≤ 0.015	0.0	100.0															
		Saskatchewan	7	≤ 0.015	0.03	0.0	71.4	28.6														
		Ontario	14	≤ 0.015	0.03	0.0	85.7	7.1	7.1													
		Québec	9	≤ 0.015	≤ 0.015	0.0	100.0															
		Maritimes	2	≤ 0.015	≤ 0.015	0.0	100.0															
	Amikacin	British Columbia	4	1	1	0.0						25.0	75.0									
		Saskatchewan	7	1	2	0.0						14.3	57.1	28.6								
		Ontario	14	2	2	0.0							50.0	50.0								
		Québec	9	1	4	0.0						11.1	66.7	11.1	11.1							
		Maritimes	2	1	1	0.0							100.0									
	Ampicillin	British Columbia	4	≤ 1	2	0.0							75.0	25.0								
		Saskatchewan	7	≤ 1	2	0.0							71.4	28.6								
		Ontario	14	16	> 32	42.9							50.0				7.1		42.9			
		Québec	9	≤ 1	> 32	44.4							55.6						44.4			
		Maritimes	2	2	2	0.0							50.0	50.0								
	Cefoxitin	British Columbia	4	4	8	0.0								50.0	25.0	25.0						
		Saskatchewan	7	2	4	0.0								57.1	42.9							
		Ontario	14	2	4	0.0								57.1	35.7	7.1						
		Québec	9	4	32	11.1							33.3	11.1	44.4			11.1				
		Maritimes	2	4	4	0.0									100.0							
	Gentamicin	British Columbia	4	≤ 0.25	≤ 0.25	0.0					100.0											
		Saskatchewan	7	≤ 0.25	0.50	0.0					57.1	42.9										
		Ontario	14	≤ 0.25	0.50	0.0					64.3	35.7										
		Québec	9	≤ 0.25	0.50	0.0					55.6	44.4										
		Maritimes	2	0.50	0.50	0.0					50.0	50.0										
II	Kanamycin	British Columbia	4	≤ 8	≤ 8	0.0										100.0						
		Saskatchewan	7	≤ 8	≤ 8	0.0										100.0						
		Ontario	14	≤ 8	> 64	14.3										85.7				14.3		
		Québec	9	≤ 8	≤ 8	0.0										100.0						
		Maritimes	2	≤ 8	≤ 8	0.0										100.0						
	Nalidixic acid	British Columbia	4	2	4	0.0								75.0	25.0							
		Saskatchewan	7	2	8	0.0								57.1	28.6	14.3						
		Ontario	14	4	4	0.0							7.1	28.6	57.1		7.1					
		Québec	9	4	4	0.0								33.3	66.7							
		Maritimes	2	4	4	0.0								50.0	50.0							
	Streptomycin	British Columbia	4	≤ 32	64	25.0												75.0	25.0			
		Saskatchewan	7	> 64	> 64	85.7												14.3		85.7		
		Ontario	14	≤ 32	64	35.7												64.3	28.6	7.1		
		Québec	9	≤ 32	> 64	22.2												77.8	11.1	11.1		
		Maritimes	2	> 64	> 64	50.0												50.0		50.0		
	Trimethoprim-sulfamethoxazole	British Columbia	4	0.25	0.25	0.0				50.0	50.0											
		Saskatchewan	7	0.25	0.25	0.0					100.0											
		Ontario	14	0.25	> 4	14.3				42.9	35.7	7.1				14.3						
		Québec	9	0.25	1	0.0				33.3	44.4	11.1	11.1									
		Maritimes	2	≤ 0.12	≤ 0.12	0.0				100.0												
	Chloramphenicol	British Columbia	4	4	8	0.0									75.0	25.0						
		Saskatchewan	7	> 32	> 32	57.1										42.9			57.1			
		Ontario	14	8	> 32	28.6									7.1	57.1	7.1	7.1	21.4			
		Québec	9	8	> 32	11.1									22.2	55.6	11.1		11.1			
		Maritimes	2	8	8	0.0								50.0		50.0						
	Sulfisoxazole	British Columbia	4	64	64	0.0											25.0	25.0	50.0			
		Saskatchewan	7	> 256	> 256	85.7												14.3				85.7
III		Ontario	14	128	> 256	42.9												35.7	14.3	7.1		42.9
		Québec	9	32	> 256	33.3												66.7				33.3
		Maritimes	2	32	32	0.0												100.0				
	Tetracycline	British Columbia	4	> 32	> 32	75.0									25.0				75.0			
		Saskatchewan	7	> 32	> 32	71.4									28.6				71.4			
		Ontario	14	≤ 4	> 32	35.7									57.1	7.1	7.1	14.3	14.3			
		Québec	9	≤ 4	> 32	44.4									55.6			11.1	33.3			
		Maritimes	2	> 32	> 32	100.0													100.0			
IV																						

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.
The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

TABLE B.22. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from pigs; *Surveillance of Animal Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	158	2	16	1.3							48.7	5.7	3.2	10.8	30.4	0.6	0.6			
	Ceftiofur	158	1	1	1.3						7.6	87.3	3.8			1.3					
	Ceftriaxone	158	≤ 0.25	≤ 0.25	1.3					98.7						0.6	0.6				
	Ciprofloxacin	158	≤ 0.015	≤ 0.015	0.0	94.9	5.1														
II	Amikacin	158	1	2	0.0						1.3	56.3	39.2	2.5	0.6						
	Ampicillin	158	2	> 32	44.9							45.6	5.7	3.2		0.6	0.6	44.3			
	Cefoxitin	158	2	4	1.9							3.2	53.8	36.7	3.8	0.6	0.6	1.3			
	Gentamicin	158	0.50	1	1.9					35.4	51.3	10.8			0.6	0.6	1.3				
	Kanamycin	158	≤ 8	> 64	17.7										81.6	0.6			17.7		
	Nalidixic acid	158	4	4	0.0								36.1	60.8	3.2						
	Streptomycin	158	64	> 64	55.7												44.3	23.4	32.3		
	Trimethoprim-sulfamethoxazole	158	0.25	2	9.5				48.7	36.1	5.1		0.6		9.5						
III	Chloramphenicol	158	8	> 32	34.8									8.9	51.9	4.4		34.8			
	Sulfisoxazole	158	> 256	> 256	58.9											4.4	32.9	3.8			58.9
	Tetracycline	158	32	> 32	65.8									32.9	1.3	0.6	16.5	48.7			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.23. Distribution of minimal inhibitory concentrations for antimicrobials in *Escherichia coli* isolates from pigs; *Farm Surveillance*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	1,425	4	8	1.2							3.2	27.9	39.4	26.9	1.3	1.0	0.2			
	Ceftiofur	1,425	0.25	0.50	1.1				3.9	52.7	41.5	0.6		0.2	0.6	0.4					
	Ceftriaxone	1,425	≤ 0.25	≤ 0.25	1.3					98.7	0.1			0.2	0.7	0.3	0.1				
	Ciprofloxacin	1,425	≤ 0.015	≤ 0.015	0.0	97.9	1.7	0.2	0.1	0.1											
II	Amikacin	1,425	2	4	0.0						1.3	30.2	56.6	10.6	1.2	0.1					
	Ampicillin	1,425	2	> 32	34.0							9.3	40.8	14.5	1.1	0.3	0.3	33.8			
	Cefoxitin	1,425	4	8	1.3						0.4	1.2	24.3	62.3	9.9	0.6	0.4	0.8			
	Gentamicin	1,425	0.50	1	1.0					18.4	63.3	15.7	1.1	0.1	0.4	0.4	0.6				
	Kanamycin	1,425	≤ 8	> 64	14.5										84.8	0.3	0.4	0.8	13.8		
	Nalidixic acid	1,425	2	4	0.4						0.5	12.4	76.6	10.2			0.1	0.2			
	Streptomycin	1,425	≤ 32	> 64	34.4												65.6	16.1	18.2		
	Trimethoprim-sulfamethoxazole	1,425	0.25	> 4	10.0				45.3	33.8	9.4	1.3	0.1		10.0						
III	Chloramphenicol	1,425	8	> 32	18.9								2.5	32.9	40.4	5.3	8.6	10.3			
	Sulfisoxazole	1,425	32	> 256	47.9											48.1	3.6	0.3	0.2		47.9
	Tetracycline	1,425	> 32	> 32	79.4									20.4	0.2	0.9	4.5	74.0			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.24. Distribution of minimal inhibitory concentrations for antimicrobials in *Escherichia coli* isolates from pigs; *Abattoir Surveillance*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	150	4	8	0.7							2.0	22.7	42.7	30.0	2.0	0.7				
	Ceftiofur	150	0.25	0.50	0.7				4.0	48.7	46.0	0.7			0.7						
	Ceftriaxone	150	≤ 0.25	≤ 0.25	0.7					98.7	0.7					0.7					
	Ciprofloxacin	150	≤ 0.015	≤ 0.015	0.0	99.3				0.7											
II	Amikacin	150	2	4	0.0						2.0	27.3	54.0	15.3	1.3						
	Ampicillin	150	4	> 32	33.3							5.3	42.7	17.3	1.3			33.3			
	Cefoxitin	150	4	8	0.0							1.3	23.3	63.3	10.7	1.3					
	Gentamicin	150	0.50	1	2.0					12.0	67.3	17.3		1.3		2.0					
	Kanamycin	150	≤ 8	> 64	18.7										81.3			0.7	18.0		
	Nalidixic acid	150	2	4	0.7						1.3	8.7	79.3	10.0				0.7			
	Streptomycin	150	≤ 32	> 64	35.3												64.7	18.0	17.3		
	Trimethoprim-sulfamethoxazole	150	0.25	> 4	13.3				32.0	34.0	16.7	3.3	0.7		13.3						
III	Chloramphenicol	150	8	32	24.7								1.3	28.0	42.0	4.0	16.7	8.0			
	Sulfisoxazole	150	> 256	> 256	52.0											46.0	2.0				52.0
	Tetracycline	150	> 32	> 32	84.7									15.3		0.7	4.0	80.0			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.25. Distribution of minimal inhibitory concentrations for antimicrobials in *Escherichia coli* isolates from pork; *Retail Meat Surveillance*, 2008.

	Antimicrobial	Province/region	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
				MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	Amoxicillin-clavulanic acid	British Columbia	44	4	8	6.8							4.5	15.9	52.3	20.5		2.3	4.5			
		Saskatchewan	41	4	8	7.3							2.4	29.3	56.1	4.9		4.9	2.4			
		Ontario	155	4	8	0.6							1.9	30.3	54.2	12.3	0.6	0.6				
		Québec	60	4	8	3.3							3.3	36.7	40.0	16.7		1.7	1.7			
		Maritimes	17	4	8	0.0							5.9	29.4	41.2	23.5						
	Ceftiofur	British Columbia	44	0.25	0.50	6.8				6.8	47.7	36.4	2.3			4.5	2.3					
		Saskatchewan	41	0.25	0.50	7.3				2.4	51.2	39.0				4.9	2.4					
		Ontario	155	0.25	0.50	0.6				4.5	54.2	40.0	0.6			0.6						
		Québec	60	0.25	0.50	3.3				8.3	53.3	33.3	1.7			1.7	1.7					
I		Maritimes	17	0.25	0.50	0.0				5.9	70.6	23.5										
	Ceftriaxone	British Columbia	44	≤ 0.25	≤ 0.25	6.8					93.2					2.3	4.5					
		Saskatchewan	41	≤ 0.25	≤ 0.25	7.3					92.7					2.4	2.4	2.4				
		Ontario	155	≤ 0.25	≤ 0.25	0.6					99.4					0.6						
		Québec	60	≤ 0.25	≤ 0.25	3.3					96.7					1.7		1.7				
		Maritimes	17	≤ 0.25	≤ 0.25	0.0					100.0											
	Ciprofloxacin	British Columbia	44	≤ 0.015	≤ 0.015	0.0	100.0															
		Saskatchewan	41	≤ 0.015	≤ 0.015	0.0	97.6				2.4											
		Ontario	155	≤ 0.015	≤ 0.015	0.0	99.4	0.6														
		Québec	60	≤ 0.015	≤ 0.015	1.7	95.0			1.7	1.7					1.7						
		Maritimes	17	≤ 0.015	≤ 0.015	0.0	100.0															
	Amikacin	British Columbia	44	2	4	0.0							20.5	56.8	22.7							
		Saskatchewan	41	2	4	0.0							17.1	51.2	29.3	2.4						
		Ontario	155	2	4	0.0							14.8	70.3	14.2	0.6						
		Québec	60	2	4	0.0							21.7	56.7	21.7							
		Maritimes	17	2	2	0.0							29.4	64.7	5.9							
	Ampicillin	British Columbia	44	2	> 32	22.7							13.6	40.9	22.7				22.7			
		Saskatchewan	41	2	4	9.8							12.2	51.2	26.8				9.8			
		Ontario	155	2	> 32	16.8							11.6	43.9	26.5	1.3			16.8			
		Québec	60	2	> 32	18.3							13.3	56.7	10.0	1.7			18.3			
		Maritimes	17	2	> 32	17.6							11.8	47.1	23.5				17.6			
	Cefoxitin	British Columbia	44	4	8	6.8								27.3	45.5	18.2	2.3		6.8			
		Saskatchewan	41	4	8	7.3							2.4	17.1	61.0	12.2			7.3			
		Ontario	155	4	8	0.6							0.6	23.2	60.0	12.9	2.6		0.6			
		Québec	60	4	8	3.3							3.3	28.3	51.7	13.3		1.7	1.7			
		Maritimes	17	4	4	0.0							5.9	29.4	58.8	5.9						
	Gentamicin	British Columbia	44	0.50	1	4.5					9.1	65.9	20.5				2.3	2.3				
		Saskatchewan	41	0.50	1	2.4					7.3	63.4	26.8					2.4				
		Ontario	155	0.50	1	3.2					3.9	72.3	20.0			0.6	1.9	1.3				
		Québec	60	0.50	1	1.7					6.7	70.0	18.3	3.3				1.7				
		Maritimes	17	0.50	1	0.0					17.6	70.6	11.8									
II	Kanamycin	British Columbia	44	≤ 8	≤ 8	2.3										95.5	2.3			2.3		
		Saskatchewan	41	≤ 8	≤ 8	2.4										95.1	2.4			2.4		
		Ontario	155	≤ 8	≤ 8	3.2										96.1	0.6			3.2		
		Québec	60	≤ 8	≤ 8	1.7										96.7	1.7			1.7		
		Maritimes	17	≤ 8	> 64	11.8										88.2				11.8		
	Nalidixic acid	British Columbia	44	2	2	0.0							18.2	72.7	9.1							
		Saskatchewan	41	2	2	2.4							17.1	78.0	2.4				2.4			
		Ontario	155	2	2	0.0							11.6	81.3	7.1							
		Québec	60	2	4	5.0						1.7	16.7	70.0	6.7				5.0			
		Maritimes	17	2	2	0.0							11.8	82.4	5.9							
	Streptomycin	British Columbia	44	≤ 32	> 64	22.7												77.3	11.4	11.4		
		Saskatchewan	41	≤ 32	64	14.6												85.4	9.8	4.9		
		Ontario	155	≤ 32	64	14.2												85.8	5.8	8.4		
		Québec	60	≤ 32	64	13.3												86.7	8.3	5.0		
		Maritimes	17	≤ 32	64	11.8												88.2	11.8			
	Trimethoprim-sulfamethoxazole	British Columbia	44	≤ 0.12	0.50	6.8				56.8	31.8	2.3	2.3			6.8						
		Saskatchewan	41	≤ 0.12	0.25	0.0				56.1	39.0	2.4	2.4									
		Ontario	155	≤ 0.12	0.50	7.1				56.8	27.7	6.5	1.9			7.1						
		Québec	60	≤ 0.12	> 4	10.0				58.3	25.0	6.7				10.0						
		Maritimes	17	0.25	> 4	11.8				35.3	47.1		5.9			11.8						
	Chloramphenicol	British Columbia	44	8	8	4.5								4.5	43.2	47.7		2.3	2.3			
		Saskatchewan	41	8	8	0.0								4.9	41.5	48.8	4.9					
		Ontario	155	4	8	9.0								3.9	50.3	36.1	0.6	3.9	5.2			
		Québec	60	4	16	6.7								6.7	50.0	33.3	3.3	3.3	3.3			
		Maritimes	17	8	8	5.9									41.2	52.9			5.9			
	Sulfisoxazole	British Columbia	44	≤ 16	> 256	27.3											72.7					27.3
		Saskatchewan	41	≤ 16	> 256	12.2											80.5	7.3				12.2
III		Ontario	155	≤ 16	> 256	20.6											72.9	6.5				20.6
		Québec	60	≤ 16	> 256	23.3											65.0	11.7				23.3
		Maritimes	17	≤ 16	> 256	17.6											76.5		5.9			17.6
	Tetracycline	British Columbia	44	≤ 4	> 32	45.5									54.5		4.5	4.5	36.4			
		Saskatchewan	41	≤ 4	> 32	29.3									70.7		2.4		26.8			
		Ontario	155	≤ 4	> 32	38.1									61.9		0.6	0.6	36.8			
		Québec	60	≤ 4	> 32	35.0									65.0			3.3	31.7			
		Maritimes	17	≤ 4	> 32	41.2									58.8			5.9	35.3			
IV																						

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.
The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

TABLE B.26. Distribution of minimal inhibitory concentrations for antimicrobials in *Enterococcus* isolates from pigs, by *Enterococcus* species; *Farm Surveillance*, 2008.

	Antimicrobial	Species	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)																
				MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1,024	2,048	> 2,048
	Ciprofloxacin	*Enterococcus faecalis*	918	1	2	0.2					0.1	2.8	70.2	26.7		0.2								
	Ciprofloxacin	*Enterococcus faecium*	60	2	4	33.3						3.3	31.7	31.7	26.7	6.7								
	Ciprofloxacin	*Enterococcus* spp.	288	0.5	1	1.0					14.2	60.4	17.4	6.9	0.7	0.3								
	Daptomycin	*Enterococcus faecalis*	918	1	1	0.1						20.2	75.3	4.4	0.1		0.1							
	Daptomycin	*Enterococcus faecium*	60	2	4	0.0						10.0	10.0	38.3	41.7									
	Daptomycin	*Enterococcus* spp.	288	1	4	0.0						19.4	39.2	30.6	10.8									
	Linezolid	*Enterococcus faecalis*	918	2	2	0.0						2.6	24.8	72.4	0.1									
I	Linezolid	*Enterococcus faecium*	60	2	2	0.0							6.7	93.3										
	Linezolid	*Enterococcus* spp.	288	2	2	0.0						5.6	39.9	54.5										
	Tigecycline	*Enterococcus faecalis*	918	0.25	0.25	1.6	0.3	1.2	3.2	37.6	50.1	6.0	1.6											
	Tigecycline	*Enterococcus faecium*	60	0.12	0.5	1.7			1.7	50.0	35.0	11.7	1.7											
	Tigecycline	*Enterococcus* spp.	288	0.12	0.25	2.1		2.1	13.2	52.8	25.0	4.9	2.1											
	Vancomycin	*Enterococcus faecalis*	918	1	2	0.0						0.7	80.0	19.1	0.3									
	Vancomycin	*Enterococcus faecium*	60	≤ 0.5	2	0.0						66.7	16.7	13.3	3.3									
	Vancomycin	*Enterococcus* spp.	288	≤ 0.5	2	0.0						65.3	21.5	4.9	4.9	3.5								
	Erythromycin	*Enterococcus faecalis*	918	> 8	> 8	77.8						5.7	13.0	3.4	0.2	0.9	76.9							
	Erythromycin	*Enterococcus faecium*	60	2	> 8	13.3						26.7	11.7	31.7	16.7	3.3	10.0							
	Erythromycin	*Enterococcus* spp.	288	> 8	> 8	65.6						32.6	1.4	0.3		1.7	63.9							
	Gentamicin	*Enterococcus faecalis*	918	≤ 128	256	8.1													89.8	2.2	4.4	2.1	1.6	
	Gentamicin	*Enterococcus faecium*	60	≤ 128	≤ 128	0.0													100.0					
	Gentamicin	*Enterococcus* spp.	288	≤ 128	≤ 128	1.7													96.9	1.4		1.0	0.7	
	Kanamycin	*Enterococcus faecalis*	918	≤ 128	> 1,024	34.0													65.0	0.7	0.3	0.1	33.9	
	Kanamycin	*Enterococcus faecium*	60	≤ 128	512	8.3													60.0	18.3	13.3		8.3	
	Kanamycin	*Enterococcus* spp.	288	≤ 128	> 1,024	23.3													75.3	0.7	0.7	0.3	22.9	
	Lincomycin[a]	*Enterococcus faecium*	60	16	> 32	88.3							8.3		3.3	6.7	35.0	13.3	33.3					
	Lincomycin	*Enterococcus* spp.	288	> 32	> 32	97.6							0.7	1.7			7.3	11.5	78.8					
II	Penicillin	*Enterococcus faecalis*	918	4	4	0.0						0.4	0.2	20.5	78.2	0.7								
	Penicillin	*Enterococcus faecium*	60	2	8	3.3						8.3	15.0	30.0	36.7	6.7	3.3							
	Penicillin	*Enterococcus* spp.	288	1	16	11.8						43.4	21.9	4.9	11.1	6.9	5.2	6.6						
	Quinupristin-dalfopristin[a]	*Enterococcus faecium*	60	2	4	11.7							30.0	58.3	10.0	1.7								
	Quinupristin-dalfopristin	*Enterococcus* spp.	288	4	8	51.7							6.9	41.3	21.9	27.4	2.4							
	Streptomycin	*Enterococcus faecalis*	918	≤ 512	> 2,048	47.2																52.8	3.9	13.8	29.4
	Streptomycin	*Enterococcus faecium*	60	≤ 512	≤ 512	8.3																91.7	6.7		1.7
	Streptomycin	*Enterococcus* spp.	288	≤ 512	> 2,048	28.8																71.2	7.6	8.7	12.5
	Tylosin	*Enterococcus faecalis*	918	> 32	> 32	78.0					0.1		8.4	13.1		0.4		0.1	77.9					
	Tylosin	*Enterococcus faecium*	60	4	> 32	10.0							25.0	20.0	33.3	11.7			10.0					
	Tylosin	*Enterococcus* spp.	288	> 32	> 32	66.3					0.3	0.3	6.6	22.6	3.5		0.3	0.3	66.0					
	Chloramphenicol	*Enterococcus faecalis*	918	8	8	7.4							0.1	0.4	10.3	79.5	2.2	2.5	4.9					
	Chloramphenicol	*Enterococcus faecium*	60	4	8	0.0								1.7	70.0	26.7	1.7							
	Chloramphenicol	*Enterococcus* spp.	288	4	8	5.9								5.2	56.9	31.6	0.3	3.5	2.4					
	Nitrofurantoin	*Enterococcus faecalis*	918	8	16	0.9								0.1	1.2	74.8	21.2	0.4	1.3	0.9				
III	Nitrofurantoin	*Enterococcus faecium*	60	64	64	6.7											13.3	1.7	78.3	6.7				
	Nitrofurantoin	*Enterococcus* spp.	288	32	> 64	18.8								0.3	2.4	17.7	6.9	35.8	18.1	18.8				
	Tetracycline	*Enterococcus faecalis*	918	> 32	> 32	93.8									6.0	0.2	1.3	3.9	88.6					
	Tetracycline	*Enterococcus faecium*	60	≤ 4	> 32	40.0									60.0			3.3	36.7					
	Tetracycline	*Enterococcus* spp.	288	> 32	> 32	83.3									16.0	0.7	1.7	3.5	78.1					
	Flavomycin	*Enterococcus faecalis*	918	≤ 1	≤ 1	0.4							93.4	6.2				0.4						
IV	Flavomycin	*Enterococcus faecium*	60	> 16	> 16	93.3								3.3		1.7	1.7	93.3						
	Flavomycin	*Enterococcus* spp.	288	16	> 16	48.3							17.4	9.4	9.0	8.7	7.3	48.3						

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

[a] Resistance to quinupristin-dalfopristin and lincomycin is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

Turkeys

TABLE B.27. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from turkeys; *Surveillance of Animal Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles MIC 50	Percentiles MIC 90	% R	Distribution (%) of MICs (µg/mL) ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	32	> 32	> 32	56.3							43.8					3.1	53.1			
	Ceftiofur	32	> 8	> 8	56.3						15.6	25.0	3.1			56.3					
	Ceftriaxone	32	16	32	56.3					43.8						15.6	31.3	6.3	3.1		
	Ciprofloxacin	32	≤ 0.015	≤ 0.015	0.0	96.9		3.1													
II	Amikacin	32	2	2	0.0						3.1	46.9	40.6	9.4							
	Ampicillin	32	> 32	> 32	56.3							40.6	3.1					56.3			
	Cefoxitin	32	32	> 32	56.3						3.1	6.3	25.0	6.3	3.1		9.4	46.9			
	Gentamicin	32	0.50	> 16	28.1					18.8	46.9	3.1	3.1				28.1				
	Kanamycin	32	≤ 8	> 64	15.6										78.1	3.1	3.1		15.6		
	Nalidixic acid	32	4	4	0.0								21.9	75.0	3.1						
	Streptomycin	32	≤ 32	> 64	40.6												59.4	9.4	31.3		
	Trimethoprim-sulfamethoxazole	32	≤ 0.12	0.25	3.1				68.8	28.1					3.1						
III	Chloramphenicol	32	8	8	3.1									31.3	65.6			3.1			
	Sulfisoxazole	32	32	> 256	31.3											21.9	37.5	9.4			31.3
	Tetracycline	32	≤ 4	> 32	43.8									56.3				43.8			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

Horses

TABLE B.28. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from horses; *Surveillance of Animal Clinical Isolates*, 2008.

	Antimicrobial	n	Percentiles MIC 50	Percentiles MIC 90	% R	Distribution (%) of MICs (µg/mL) ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	62	8	32	11.3							46.8	1.6		12.9	27.4	1.6	9.7			
	Ceftiofur	62	1	> 8	11.3						32.3	56.5				11.3					
	Ceftriaxone	62	≤ 0.25	16	11.3					88.7						9.7	1.6				
	Ciprofloxacin	62	≤ 0.015	0.25	0.0	58.1	1.6			40.3											
II	Amikacin	62	1	16	0.0						1.6	50.0	12.9	1.6	4.8	21.0	8.1				
	Ampicillin	62	> 32	> 32	51.6							46.8	1.6					51.6			
	Cefoxitin	62	2	32	11.3							35.5	41.9	11.3			8.1	3.2			
	Gentamicin	62	0.50	> 16	41.9					33.9	22.6	1.6					41.9				
	Kanamycin	62	≤ 8	> 64	41.9										58.1				41.9		
	Nalidixic acid	62	4	16	0.0								14.5	45.2	27.4	12.9					
	Streptomycin	62	≤ 32	≤ 32	4.8												95.2	3.2	1.6		
	Trimethoprim-sulfamethoxazole	62	0.25	> 4	41.9				43.5	14.5					41.9						
III	Chloramphenicol	62	8	> 32	16.1									27.4	56.5			16.1			
	Sulfisoxazole	62	64	> 256	41.9											8.1	30.6	19.4			41.9
	Tetracycline	62	≤ 4	≤ 4	3.2									93.5	3.2			3.2			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

TABLE B.29. Distribution of minimal inhibitory concentrations for antimicrobials in *Salmonella* isolates from animal feed; *Feed and Feed Ingredients*, 2008.

	Antimicrobial	n	Percentiles		% R	Distribution (%) of MICs (µg/mL)														
			MIC 50	MIC 90		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	57	≤ 1	≤ 1	1.8							94.7	1.8			1.8		1.8			
	Ceftiofur	57	1	1	1.8						15.8	82.5				1.8					
	Ceftriaxone	57	≤ 0.25	≤ 0.25	1.8					98.2								1.8			
	Ciprofloxacin	57	≤ 0.015	≤ 0.015	0.0	94.7	5.3														
II	Amikacin	57	1	2	0.0						3.5	49.1	45.6	1.8							
	Ampicillin	57	≤ 1	≤ 1	3.5							94.7	1.8					3.5			
	Cefoxitin	57	4	4	1.8							1.8	42.1	49.1	5.3			1.8			
	Gentamicin	57	≤ 0.25	0.50	0.0					54.4	36.8	8.8									
	Kanamycin	57	≤ 8	≤ 8	0.0										100.0						
	Nalidixic acid	57	4	4	0.0								42.1	57.9							
	Streptomycin	57	≤ 32	≤ 32	8.8												91.2	7.0	1.8		
	Trimethoprim-sulfamethoxazole	57	≤ 0.12	0.25	1.8				75.4	22.8					1.8						
III	Chloramphenicol	57	8	8	3.5								1.8	26.3	68.4			3.5			
	Sulfisoxazole	57	32	64	5.3											24.6	42.1	28.1			5.3
	Tetracycline	57	≤ 4	≤ 4	5.3									94.7			1.8	3.5			
IV																					

Information on how to interpret the MIC tables is provided at the beginning of Appendix B.

Appendix C – Additional Tables and Figures

Antimicrobial Resistance

TABLE C.1. Distribution of *Salmonella* isolates from humans, by patient age and province; *Surveillance of Human Clinical Isolates*, 2008.

Age (year)	Number (%) of isolates	Province	Number (%) of isolates
Less than 5	302 (8)	British Columbia	507 (14)
5 to 12	283 (8)	Alberta	428 (12)
13 to 17	136 (4)	Saskatchewan	184 (5)
18 to 29	546 (15)	Manitoba	248 (7)
30 to 49	654 (18)	Ontario	1,337 (37)
50 to 69	451 (13)	Québec	582 (16)
70 and more	222 (6)	Nova Scotia	128 (4)
Not specified	1,007 (28)	New Brunswick	107 (3)
		Prince Edward Island	22 (1)
		Newfoundland and Labrador	58 (2)
		Yukon	0 (0)
		Northwest Territories	0 (0)
		Nunavut	0 (0)
Total	**3,601 (100)**		**3,601 (100)**

TABLE C.2. Distribution of isolates of primary human *Salmonella* serovars from humans, by source; *Surveillance of Human Clinical Isolates*, 2008.

Specimen source	Number (%) of isolates							
	Enteritidis	Heidelberg	Newport	Paratyphi A and B	Typhi	Typhimurium	Other serovars	Total
Stool	1,058 (84)	208 (72)	147 (83)	23 (35)	41 (22)	400 (84)	921 (80)	2,798 (78)
Blood	33 (3)	34 (12)	7 (4)	35 (54)	140 (75)	16 (3)	49 (4)	314 (9)
Urine	21 (2)	6 (2)	11 (6)	1 (2)	1 (1)	11 (2)	78 (7)	129 (4)
Abscess	2 (< 1)	1 (< 1)						3 (1)
Anatomy part						1 (< 1)	1 (< 1)	2 (1)
Other body fluid							3 (< 1)	3 (1)
Unknown	144 (11)	41 (14)	12 (7)	6 (9)	4 (2)	46 (10)	99 (9)	352 (10)
Total	**1,258 (100)**	**290 (100)**	**177 (100)**	**65 (100)**	**186 (100)**	**474 (100)**	**1,151 (100)**	**3,601 (100)**

TABLE C.3. Summary of antimicrobial susceptibility in the most common isolates of *Salmonella* serovars from humans and the agri-food sector; CIPARS, 2008.

Species	Most common serovars				
	Total (n)	Susceptible to antimicrobials	1 to 4 antimicrobials in resistance pattern	5 to 8 antimicrobials in resistance pattern	9 to 15 antimicrobials in resistance pattern
Surveillance of Human Clinical Isolates					
Humans	**n = 3,601** Enteritidis (1,258) Typhimurium (474) Heidelberg (290) Typhi (186) Newport (177) I4,[5],12:i:- (124)	**n = 2,651** Enteritidis (1,076) Typhimurium (287) Heidelberg (179) Newport (168) I4,[5],12:i:- (76) Infantis (68)	**n = 686** Enteritidis (175) Typhi (106) Heidelberg (70) Typhimurium (69) Hadar (59) Paratyphi A and B (47) I4,[5],12:i:- (35) Agona (15)	**n = 244** Typhimurium (110) Heidelberg (40) Typhi (31) I4,[5],12:i:- (11) Kentucky (9) Enteritidis (7) Paratyphi B var. L(+) tartrate+ (7)	**n = 20** Typhimurium (8) I4,[5],12:i:- (2) Newport (2) Agona (1) Heidelberg (1) Rough-O:i:1,2 (1) Kentucky (1) Paratyphi A and B (1) Reading (1) Saintpaul (1) Stanley (1)
Farm Surveillance					
Pigs	**n = 61** Typhimurium (20) Brandenburg (9) Bovismorbificans (7) Derby (7) Mbandaka (4) I4,[5],12:i:- (2) Infantis (2) London (2)	**n = 23** Bovismorbificans (5) Typhimurium (5) Infantis (2) London (2) Mbandaka (2) I4,[5],12:i:- (1)	**n = 24** Brandenburg (9) Derby (7) Typhimurium (4) Bovismorbificans (2) Mbandaka (2)	**n = 14** Typhimurium (11) I4,[5],12:i:- (1)	
Abattoir Surveillance					
Chickens	**n = 234** Kentucky (93) Enteritidis (45) Heidelberg (33) Hadar (13) Typhimurium (9) Mbandaka (5) Rissen (5)	**n = 113** Enteritidis (45) Heidelberg (19) Kentucky (18) Mbandaka (5) Typhimurium (5) Montevideo (4)	**n = 93** Kentucky (58) Hadar (13) Heidelberg (8) Rissen (4) IRough:i:z6 (3) Typhimurium (2)	**n = 28** Kentucky (17) Heidelberg (6) Kiambu (2) Typhimurium (2) Infantis (1)	
Pigs	**n = 151** Typhimurium (48) Derby (33) Brandenburg (10) Infantis (8) Worthington (7) Uganda (6) Give (5) Ohio (5) Bovismorbificans (4) Mbandaka (4)	**n = 55** Infantis (7) Uganda (6) Bovismorbificans (4) Brandenburg (4) Derby (4) Give (4) Mbandaka (4) California (3) London (3) Ohiovar.14+ (3) Typhimurium (3) Havana (2) Ohio (2)	**n = 60** Derby (28) Typhimurium (13) Brandenburg (6) Worthington (6)	**n = 36** Typhimurium (32) Ohio (2) Anatum (1) Derby (1)	
Retail Meat Surveillance					
Chicken	**n = 382** Kentucky (120) Heidelberg (78) Enteritidis (62) Hadar (22) Thompson (17) Typhimurium (15) Kiambu (12) I4,[5],12:i:- (9) Schwarzengrund (9)	**n = 202** Enteritidis (62) Heidelberg (49) Kentucky (21) Thompson (16) Typhimurium (10) I4,[5],12:i:- (7) Infantis (5)	**n = 131** Kentucky (82) Hadar (20) Heidelberg (16) Schwarzengrund (5) Kiambu (3)	**n = 49** Kentucky (17) Heidelberg (13) Kiambu (6) Typhimurium (4) I4,[5],12:i:- (2) Infantis (2) Agona (1) I4,[5],12:-:- (1) I8,20:-:z6 (1) IRough:r:1,2 (1) Thompson (1)	
Pork	**n = 36** Typhimurium (11) Derby (4) Heidelberg (3) Johannesburg (3) Kentucky (3) Agona (1) Berta (1) Enteritidis (1) Give (1) I4,[5],12:i:- (1) I40:-:enx (1) IRough:z10:- (1) Krefeld (1) London (1) Ohio (1) Schwarzengrund (1) Vi:Rough:-:- (1)	**n = 11** Typhimurium (2) Berta (1) Derby (1) Enteritidis (1) Give (1) Heidelberg (1) I4,[5],12:i:- (1) IRough:z10:- (1) Krefeld (1) Ohio (1)	**n = 19** Typhimurium (4) Derby (3) Johannesburg (3) Heidelberg (2) Kentucky (2) Agona (1) I40:-:enx (1) London (1) Schwarzengrund (1) Vi:Rough:-:- (1)	**n = 6** Typhimurium (5) Kentucky (1)	

Most common serovars were those representing 2% or more of the isolates within each surveillance component and animal species.

For the purpose of this table, *S.* Typhimurium var. 5- results were combined with *S.* Typhimurium results to harmonize serovar classification with that of the National Microbiology Laboratory.

TABLE C.3 (continued). Summary of antimicrobial susceptibility in the most common isolates of *Salmonella* serovars from humans and the agri-food sector; CIPARS, 2008.

Species	Most common serovars				
	Total (n)	Susceptible to antimicrobials	1 to 4 antimicrobials in resistance pattern	5 to 8 antimicrobials in resistance pattern	9 to 15 antimicrobials in resistance pattern
Surveillance of Animal Clinical Isolates					
Cattle	**n = 134** Typhimurium (55) Kentucky (15) Cerro (13) I6,14,18:-:- (10) Heidelberg (9) Muenster (8) Enteritidis (4) Thompson (4)	**n = 82** Kentucky (15) Cerro (13) Typhimurium (12) I6,14,18:-:- (10) Muenster (8) Thompson (4) Enteritidis (3) Heidelberg (3) Montevideo (2)	**n = 14** Typhimurium (9) Heidelberg (3) Enteritidis (1) IRough:i:1,2 (1)	**n = 34** Typhimurium (31) Heidelberg (3)	**n = 4** Typhimurium (3) Agona (1)
Chickens	**n = 209** Enteritidis (99) Kentucky (38) Heidelberg (31) Typhimurium (11) I4,[5],12:i:- (5)	**n = 143** Enteritidis (99) Heidelberg (20) Typhimurium (6) Kentucky (4) I4,[5],12:i:- (3)	**n = 31** Kentucky (15) Heidelberg (5) Thompson (4) Typhimurium (2) Hadar (1) IRough:r:1,2 (1) Mbandaka (1) Ouakam (1) Tennessee (1)	**n = 31** Kentucky (19) Heidelberg (6) Typhimurium (3) I4,[5],12:i:- (2) I4,[5],12:-:1,2 (1)	**n = 4** Bredeney (2) I4,[5],12:-:1,2 (1) Mbandaka (1)
Pigs	**n = 158** Typhimurium (88) Derby (15) I4,[5],12:i:- (8) Brandenburg (7) Infantis (5) Enteritidis (4)	**n = 45** Typhimurium (15) Brandenburg (7) Enteritidis (4) Infantis (3) Worthington (3) Cerro (2) I4,[5],12:i:- (2) Berta (1) Bovismorbificans (1) California (1) Derby (1) Krefeld (1) Mbandaka (1) Ohio (1) Senftenberg (1) Thompson (1)	**n = 52** Typhimurium (21) Derby (14) Heidelberg (2) I4,[5],12:i:- (2) Orion (2) Rissen (2)	**n = 60** Typhimurium (52) I4,[5],12:i:- (4)	**n = 1** Infantis (1)
Turkeys	**n = 32** Typhimurium (7) Agona (4) Hadar (4) Heidelberg (4) Bredeney (3) Senftenberg (3) Anatum (1) Give (1) I4,[5],12:-:- (1) Manhattan (1) Montevideo (1) Ouakam (1) Saintpaul (1)	**n = 3** Give (1) Manhattan (1) Saintpaul (1)	**n = 10** Hadar (4) Heidelberg (4) Anatum (1) Ouakam (1)	**n = 14** Typhimurium (7) Agona (4) I4,[5],12:-:- (1) Montevideo (1) Senftenberg (1)	**n = 5** Bredeney (3) Senftenberg (2)
Horses	**n = 62** Heidelberg (26) Newport (8) Typhimurium (7) Litchfield (5) Thompson (5) Oranienburg (4) Agona (2)	**n = 28** Newport (8) Typhimurium (7) Thompson (5) Oranienburg (4) Bovismorbificans (1) Braenderup (1) Cerro (1) Rubislaw (1)	**n = 2** Agona (2)	**n = 31** Heidelberg (25) Litchfield (5) Kiambu (1)	**n = 1** Heidelberg (1)

Most common serovars were those representing 2% or more of the isolates within each surveillance component and animal species.

For the purpose of this table, *S.* Typhimurium var. 5- results were combined with *S.* Typhimurium results to harmonize serovar classification with that of the National Microbiology Laboratory.

TABLE C.4. Summary of selected resistance patterns involving multiple antimicrobials in bacterial isolates from humans and the agri-food sector; CIPARS, 2008.

Species	Bacterial species	Number (%) of isolates / Serovar total Number (%) of isolates / *Salmonella* total							
		Susceptible to all antimicrobials	Resistant to A2C-AMP	ACSSuT	AKSSuT	ACKSSuT	A2C-ACSSuT	A2C-AKSSuT	A2C-ACKSSuT
Surveillance of Human Clinical Isolates									
Humans	*Salmonella* Enteritidis (n = 1,258)	1,076/1,258 (86%) 1,076/3,601 (30%)	2/1,258 (< 1%) 2/3,601 (< 1%)		1/1,258 (< 1%) 1/3,601 (< 1%)				
	Salmonella Heidelberg (n = 290)	179/290 (62%) 179/3,601 (5%)	37/290 (13%) 37/3,601 (1%)						1/290 (< 1%) 1/3,601 (< 1%)
	Salmonella Newport (n = 177)	168/177 (95%) 168/3,601 (5%)		1/177 (< 1%) 1/3,601 (< 1%)	1/177 (< 1%) 1/3,601 (< 1%)		2/177 (1%) 2/3,601 (< 1%)		
	Salmonella Paratyphi A and B (n = 65)	15/65 (23%) 15/3,601 (< 1%)		2/65 (3%) 2/3,601 (< 1%)					1/65 (2%) 1/3,601 (< 1%)
	Salmonella Typhi (n = 186)	49/186 (26%) 49/3,601 (1%)		7/186 (4%) 7/3,601 (< 1%)					
	Salmonella Typhimurium (n = 474)	287/474 (61%) 287/3,601 (8%)	3/474 (< 1%) 3/3,601 (< 1%)	69/474 (15%) 69/3,601 (2%)	11/474 (2%) 11/3,601 (< 1%)	21/474 (4%) 21/3,601 (< 1%)	6/474 (1%) 6/3,601 (< 1%)	1/474 (< 1%) 1/3,601 (< 1%)	
	Other Serovars (n = 1,151)	877/1,151 (76%) 877/3,601 (24%)	12/1,151 (1%) 12/3,601 (< 1%)	14/1,151 (1%) 14/3,601 (< 1%)	1/1,151 (< 1%) 1/3,601 (< 1%)	2/1,151 (< 1%) 2/3,601 (< 1%)	5/1,151 (< 1%) 5/3,601 (< 1%)		1/1,151 (< 1%) 1/3,601 (< 1%)
Farm Surveillance									
Pigs	*Salmonella* Enteritidis (n = 1)	1/1 (100%) 1/61 (2%)							
	Salmonella Typhimurium (n = 20)	5/20 (25%) 5/61 (8%)		3/20 (15%) 3/61 (5%)		8/20 (40%) 8/61 (13%)			
	Other Serovars (n = 40)	17/40 (43%) 17/61 (28%)		1/40 (3%) 1/61 (2%)	1/40 (3%) 1/61 (2%)	1/40 (3%) 1/61 (2%)			
	Escherichia coli (n = 1,425)	194/1,425 (14%)		29/1,425 (2%)	34/1,425 (2%)	10/1,425 (< 1%)		2/1,425 (< 1%)	
Abattoir Surveillance									
Beef cattle	*Escherichia coli* (n = 176)	107/176 (61%)							
Chickens	*Salmonella* Enteritidis (n = 45)	45/45 (100%) 45/234 (19%)							
	Salmonella Heidelberg (n = 33)	19/33 (58%) 19/234 (8%)	6/33 (18%) 6/234 (3%)						
	Salmonella Typhimurium (n = 9)	5/9 (56%) 5/234 (2%)	1/9 (11%) 1/234 (< 1%)	1/9 (11%) 1/234 (< 1%)					
	Other Serovars (n = 147)	44/147 (30%) 44/234 (19%)	18/147 (12%) 18/234 (8%)						
	Escherichia coli (n = 170)	39/170 (23%)	31/170 (18%)	1/170 (< 1%)	5/170 (3%)		2/170 (1%)		1/170 (< 1%)
Pigs	*Salmonella* Enteritidis (n = 1)	1/1 (100%) 1/151 (< 1%)							
	Salmonella Typhimurium (n = 48)	3/48 (6%) 3/151 (2%)		21/48 (44%) 21/151 (14%)		11/48 (23%) 11/151 (7%)			
	Other Serovars (n = 102)	51/102 (50%) 51/151 (34%)	1/102 (< 1%) 1/151 (< 1%)	2/102 (2%) 2/151 (1%)					
	Escherichia coli (n = 150)	17/150 (11%)		2/150 (1%)	9/150 (6%)	3/150 (2%)			
Retail Meat Surveillance									
Beef	*Escherichia coli* (n = 572)	444/572 (78%)	6/572 (1%)	2/572 (< 1%)	2/572 (< 1%)			1/572 (< 1%)	
Chicken	*Salmonella* Enteritidis (n = 62)	62/62 (100%) 62/382 (16%)							
	Salmonella Heidelberg (n = 78)	49/78 (63%) 49/382 (13%)	13/78 (17%) 13/382 (3%)						
	Salmonella Typhimurium (n = 15)	10/15 (67%) 10/382 (3%)	2/15 (13%) 2/382 (< 1%)	2/15 (13%) 2/382 (< 1%)					
	Other Serovars (n = 227)	81/227 (36%) 81/382 (21%)	28/227 (12%) 28/382 (7%)						
	Escherichia coli (n = 479)	143/479 (30%)	99/479 (21%)	3/479 (< 1%)	3/479 (< 1%)		12/479 (3%)	5/479 (1%)	2/479 (< 1%)
Pork	*Salmonella* Enteritidis (n = 1)	1/1 (100%) 1/36 (3%)							
	Salmonella Heidelberg (n = 3)	1/3 (33%) 1/36 (3%)							
	Salmonella Typhimurium (n = 11)	2/11 (18%) 2/36 (6%)		3/11 (27%) 3/36 (8%)					
	Other Serovars (n = 21)	7/21 (33%) 7/36 (19%)	1/21 (5%) 1/36 (3%)						
	Escherichia coli (n = 317)	183/317 (58%)	8/317 (3%)	3/317 (< 1%)	1/317 (< 1%)	1/317 (< 1%)	1/317 (< 1%)		

Results for each of the above specific patterns exclude isolates resistant to one of the other patterns presented in this table but may include isolates resistant to other antimicrobials. Blank cells represent values equal to zero (0%).

For the purpose of this table, *S.* Typhimurium var. 5- results were combined with *S.* Typhimurium results to harmonize serovar classification with that of the National Microbiology Laboratory.

TABLE C.4 (continued). Summary of selected resistance patterns involving multiple antimicrobials in bacterial isolates from humans and the agri-food sector; CIPARS, 2008.

Species	Bacterial species	Number (%) of isolates / Serovar total Number (%) of isolates / *Salmonella* total							
		Susceptible to all antimicrobials	Resistant to A2C-AMP	ACSSuT	AKSSuT	ACKSSuT	A2C-ACSSuT	A2C-AKSSuT	A2C-ACKSSuT
Surveillance of Animal Clinical Isolates									
Cattle	*Salmonella* Enteritidis (n = 4)	3/4 (75%) 3/134 (2%)							
	Salmonella Heidelberg (n = 9)	3/9 (33%) 3/134 (2%)	2/9 (22%) 2/134 (1%)						
	Salmonella Typhimurium (n = 55)	12/55 (22%) 12/134 (9%)		9/55 (16%) 9/134 (7%)	5/55 (9%) 5/134 (4%)	17/55 (31%) 17/134 (13%)			3/55 (5%) 3/134 (2%)
	Other Serovars (n = 66)	64/66 (97%) 64/134 (48%)					1/66 (2%) 1/134 (< 1%)		
Chickens	*Salmonella* Enteritidis (n = 99)	99/99 (100%) 99/209 (47%)							
	Salmonella Heidelberg (n = 31)	20/31 (65%) 20/209 (10%)	6/31 (19%) 6/209 (3%)						
	Salmonella Typhimurium (n = 11)	6/11 (55%) 6/209 (3%)	1/11 (9%) 1/209 (< 1%)	2/11 (18%) 2/209 (< 1%)					
	Other Serovars (n = 68)	18/68 (26%) 18/209 (9%)	21/68 (31%) 21/209 (10%)				1/68 (1%) 1/209 (< 1%)	2/68 (3%) 2/209 (< 1%)	1/68 (1%) 1/209 (< 1%)
Pigs	*Salmonella* Enteritidis (n = 4)	4/4 (100%) 4/158 (3%)							
	Salmonella Heidelberg (n = 2)								
	Salmonella Typhimurium (n = 88)	15/88 (17%) 15/158 (9%)		35/88 (40%) 35/158 (22%)	2/88 (2%) 2/158 (1%)	12/88 (14%) 12/158 (8%)			
	Other Serovars (n = 64)	26/64 (41%) 26/158 (16%)	1/64 (2%) 1/158 (< 1%)	1/64 (2%) 1/158 (< 1%)		4/64 (6%) 4/158 (3%)			1/64 (2%) 1/158 (< 1%)
Turkeys	*Salmonella* Heidelberg (n = 4)								
	Salmonella Typhimurium (n = 7)		7/7 (100%) 7/32 (22%)						
	Other Serovars (n = 21)	3/21 (14%) 3/32 (9%)	8/21 (38%) 8/32 (25%)				1/21 (5%) 1/32 (3%)	2/21 (10%) 2/32 (6%)	
Horses	*Salmonella* Heidelberg (n = 26)		1/26 (4%) 1/62 (2%)						
	Salmonella Typhimurium (n = 7)	7/7 (100%) 7/62 (11%)							
	Other Serovars (n = 29)	21/29 (72%) 21/62 (34%)	6/29 (21%) 6/62 (10%)						

Results for each of the above specific patterns exclude isolates resistant to one of the other patterns presented in this table but may include isolates resistant to other antimicrobials. Blank cells represent values equal to zero (0%).

For the purpose of this table, *S.* Typhimurium var. 5- results were combined with *S.* Typhimurium results to harmonize serovar classification with that of the National Microbiology Laboratory.

TABLE C.5. Bacterial recovery rates of samples collected through the CIPARS agri-food components, 2002-2008.

CIPARS Component/ Animal species	Province	Year	Percentage (%) of isolates recovered and number of isolates recovered/number of samples submitted							
			Escherichia coli		*Salmonella*		*Campylobacter*		*Enterococcus*	
Farm Surveillance										
Pigs		2006	**99%**	459/462	**20%**	94/462			**81%**	374/462
		2007	**100%**	612/612	**21%**	136/612			**81%**	495/612
		2008	**99%**	481/486	**13%**	61/486			**92%**	448/486
Abattoir Surveillance										
Beef cattle		2002	**97%**	76/78	**1%**	3/78				
		2003	**97%**	155/159	**< 1 %**	1/114				
		2004	**98%**	167/170						
		2005	**97%**	122/126			**66%**	23/35		
		2006	**100%**	150/150			**36%**	31/87		
		2007	**99%**	188/190			**39%**	75/190		
		2008	**97%**	176/182			**71%**[b]	129/182		
Chickens		2002	**100%**	40/40	**13%**	25/195				
		2003	**97%**	150/153	**16%**	126/803				
		2004	**99%**	130/131	**16%**	142/893				
		2005	**99%**	218/220	**18%**	200/1,103				
		2006	**100%**	166/166	**23%**	187/824				
		2007	**99%**	180/181	**25%**	204/808				
		2008	**99%**	170/171	**28%**	234/851				
Pigs		2002	**97%**	38/39	**27%**	103/385				
		2003	**98%**	153/155	**28%**	395/1,393				
		2004	**99%**	142/143	**38%**	270/703				
		2005	**99%**	163/164	**42%**	212/486				
		2006	**98%**	115/117	**40%**	145/359				
		2007	**98%**	93/95	**36%**	105/296				
		2008	**100%**	150/150	**44%**	151/340				
Retail Meat Surveillance										
Beef	British Columbia	2005	**93%**	27/29						
		2007	**79%**	49/62						
		2008	**77%**	88/115						
	Saskatchewan	2005	**79%**	120/151						
		2006	**76%**	123/161						
		2007	**78%**	118/151						
		2008	**76%**	134/177						
	Ontario	2003	**66%**	101/154	**2%**	2/84	**3%**	2/76	**91%**	69/76
		2004	**80%**	190/237						
		2005	**81%**	184/227						
		2006	**81%**	189/235						
		2007	**71%**	184/227						
		2008	**78%**	185/236						
	Québec	2003	**57%**	84/147	**0%**	0/33	**0%**	0/33	**80%**	28/35
		2004	**56%**	137/245						
		2005	**56%**	126/225						
		2006	**50%**	109/215						
		2007	**68%**	147/216						
		2008	**59%**	126/214						
	Maritimes	2004	**67%**	16/24						
		2007	**52%**	16/31						
		2008	**70%**	39/56						
Chicken	British Columbia	2005	**95%**	19/20	**13%**	5/39	**69%**	27/39	**100%**	20/20
		2007	**98%**	42/43	**22%**[a]	18/81	**35%**	28/80	**100%**	34/34
		2008	**90%**	70/78	**32%**	47/145	**34%**	50/145	**100%**	78/78
	Saskatchewan	2005	**98%**	81/83	**14%**	21/153	**37%**	53/145	**98%**	83/85
		2006	**98%**	85/86	**16%**	25/153	**33%**	51/155	**98%**	85/87
		2007	**97%**	75/77	**31%**[a]	43/141	**35%**	49/141	**100%**	77/77
		2008	**99%**	91/92	**40%**	64/161	**25%**	41/161	**100%**	92/92
	Ontario	2003	**95%**	137/144	**16%**	27/167	**47%**	78/166	**99%**	143/144
		2004	**95%**	150/158	**17%**	54/315	**45%**	143/315	**100%**	158/158
		2005	**95%**	145/153	**9%**	26/303	**40%**	120/303	**99%**	150/152
		2006	**97%**	152/156	**12%**	36/311	**34%**	104/311	**98%**	154/156
		2007	**98%**	157/161	**54%**[a]	172/320	**37%**	117/320	**100%**	161/161
		2008	**96%**	150/156	**45%**	139/311	**39%**	121/311	**99%**	154/156
	Québec	2003	**89%**	112/126	**16%**	29/171	**55%**	94/170	**100%**	125/125
		2004	**96%**	157/161	**17%**	53/320	**50%**	161/322	**100%**	161/161
		2005	**95%**	142/149	**9%**	26/300	**34%**	103/299	**100%**	150/150
		2006	**94%**	135/144	**12%**	33/288	**35%**	100/288	**100%**	144/144
		2007	**90%**	129/144	**40%**[a]	113/287	**21%**	59/287	**99%**	143/144
		2008	**91%**	131/144	**42%**	120/287	**19%**	54/287	**100%**	144/144
	Maritimes	2004	**100%**	13/13	**4%**	1/25	**40%**	10/25	**100%**	13/13
		2007	**91%**	29/32	**22%**[a]	7/32				
		2008	**68%**	38/56	**22%**	12/56				

Results in the grey-shaded areas indicate isolates that were recovered but not submitted for antimicrobial susceptibility testing.
No human data are available for *Salmonella* isolates because no recovery information on samples was provided to CIPARS.
The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

[a] Enhancement to the *Salmonella* recovery method yielded higher recovery rates from retail chicken in 2007 than in prior years.

[b] Implementation of a new *Campylobacter* recovery method in 2008 in abattoir beef cattle isolates.

TABLE C.5 (continued). Bacterial recovery rates of samples collected through the CIPARS agri-food components, 2002-2008.

CIPARS Component/ Animal species	Province	Year	Percentage (%) of isolates recovered and number of isolates recovered/number of samples submitted							
			Escherichia coli		*Salmonella*		*Campylobacter*		*Enterococcus*	
Retail Meat Surveillance										
Pork	British Columbia	2005	**31%**	10/32						
		2007	**29%**	23/79	**1%**	1/79				
		2008	**30%**	44/148	**2%**	3/148				
	Saskatchewan	2005	**30%**	48/162						
		2006	**30%**	49/165	**2%**	3/134				
		2007	**25%**	38/154	**2%**	3/154				
		2008	**23%**	41/176	**1%**	1/176				
	Ontario	2003	**58%**	90/154	**1%**	1/93	**0%**	0/76	**87%**	66/76
		2004	**71%**	198/279						
		2005	**59%**	179/303						
		2006	**59%**	182/311	**< 1%**	1/255				
		2007	**54%**	172/320	**2%**	6/319				
		2008	**50%**	155/312	**2%**	7/310				
	Québec	2003	**42%**	61/147	**3%**	1/32	**9%**	3/32	**82%**	28/34
		2004	**38%**	109/290						
		2005	**26%**	79/300						
		2006	**20%**	57/287	**0%**	0/232				
		2007	**22%**	64/287	**1%**	3/288				
		2008	**21%**	60/287	**2%**	5/286				
	Maritimes	2004	**58%**	14/24						
		2007	**39%**	13/31	**3%**	1/30				
		2008	**30%**	17/56	**2%**	1/56				

Results in the grey-shaded areas indicate isolates that were recovered but not submitted for antimicrobial susceptibility testing.
No human data are available for *Salmonella* isolates because no recovery information on samples was provided to CIPARS.
The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

[a] Enhancement to the *Salmonella* recovery method yielded higher recovery rates from retail chicken in 2007 than in prior years.

[b] Implementation of a new *Campylobacter* recovery method in 2008 in abattoir beef cattle isolates.

TABLE C.6. Distribution of *Salmonella* isolates across provinces; *Surveillance of Animal Clinical Isolates*, 2008.

Species	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario	Québec	Prince Edward Island	New Brunswick	Nova Scotia	Newfoundland and Labrador
	Number (%) of isolates									
Cattle (n = 134)	5 (4)	3 (2)	6 (4)	2 (1)	87 (65)	30 (22)		1 (1)		
Chickens (n = 209)	35 (17)	23 (11)	10 (5)	9 (4)	106 (51)	18 (9)			4 (2)	4 (2)
Pigs (n = 158)	5 (3)		6 (4)	9 (6)	46 (29)	87 (55)	1 (1)	3 (2)	1 (1)	
Turkeys (n = 32)	1 (3)				20 (63)	11 (34)				
Horses (n = 62)	3 (5)			1 (2)	51 (82)	6 (10)		1 (2)		

Humans

TABLE C.7. Total volume of active ingredients of oral antimicrobials dispensed by retail pharmacies in Canada, 2000-2008.

	ATC Class		Total amount of active ingredients (kg)								
			2000	2001	2002	2003	2004	2005	2006	2007	2008
	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	7,148.28	7,295.71	7,114.06	7,492.67	7,491.56	8,414.31	8,985.63	9,798.46	10,591.00
	J01DD	Third-generation cephalosporins	441.47	412.56	372.50	321.45	275.37	282.37	274.85	303.36	322.24
I	J01MA	Fluoroquinolones	17,387.35	17,569.37	17,718.15	18,469.28	18,738.69	18,781.31	19,348.84	19,788.30	19,949.11
	J01XA	Glycopeptides	25.90	28.25	32.23	40.56	70.36	79.17	75.77	83.99	85.62
	J01XD	Imidazole	NA	4,808.34	4,927.11	5,126.54	5,237.51	5,311.07	5,563.98	5,585.72	5,793.70
	J01XX	Linezolid	NA	1.55	4.91	10.82	17.29	23.26	22.44	25.35	26.49
	J01CA	Penicillins with extended spectrum	57,566.37	56,004.37	53,404.23	53,132.75	51,471.46	53,138.73	53,534.56	53,440.34	54,564.33
	J01CE	ß-lactamase sensitive penicillins	15,079.86	14,253.92	13,722.26	13,802.13	12,916.80	13,174.53	13,139.62	12,879.95	12,390.47
	J01CF	ß-lactamase resistant penicillins	8,351.00	8,004.27	7,376.34	7,135.18	6,596.38	5,861.06	5,604.86	5,157.50	4,780.47
	J01DB	First-generation cephalosporins	16,693.30	17,295.99	18,358.43	19,683.24	20,312.94	21,585.02	22,981.10	23,345.75	24,064.50
	J01DC	Second-generation cephalosporins	11,099.40	9,857.59	8,712.26	8,570.41	8,277.23	8,410.81	7,937.42	7,423.47	7,223.45
	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	26,196.41	23,815.65	21,549.97	20,179.30	19,226.17	18,858.59	18,520.09	18,079.24	18,166.55
II	J01FA	Macrolides	25,163.98	23,844.04	21,665.44	22,138.28	21,168.11	22,746.49	22,646.85	22,513.36	22,793.59
	J01FF	Lincosamides	3,289.35	3,590.12	3,896.00	4,272.26	4,441.95	4,499.59	4,976.71	5,303.12	5,562.18
	J01GB	Aminoglycosides	29.66	0.36	0.04	< 0.01	0.01	NA	0.05	0.20	0.19
	J01MB	Other quinolones, excluding fluoroquinolones	76.31	62.19	52.12	45.35	41.87	1.05	0.26	0.02	NA
	J01RA	Sulfonamide combinations, excluding trimethoprim	2,745.17	1,910.05	1,251.28	843.14	548.87	494.05	418.86	305.33	103.26
	J01XC	Steroid antimicrobials	34.79	39.06	35.54	37.27	36.64	41.91	42.73	34.21	29.14
	J01AA	Tetracyclines	14,112.37	13,169.24	12,595.12	11,902.77	11,050.90	10,709.61	10,298.35	9,664.96	9,400.65
	J01BA	Amphenicols	0.78	0.99	0.20	NA	0.06	0.01	NA	NA	NA
	J01EA	Trimethoprim, including derivatives	315.71	297.29	310.34	307.34	288.32	265.98	265.88	260.48	242.85
III	J01EB	Short-acting sulfonamides	105.38	13.45	0.88	1.04	1.02	0.26	0.13	0.03	0.03
	J01EC	Intermediate-acting sulfonamides	28.08	4.48	4.77	5.55	4.51	2.93	2.27	2.36	1.34
	J01XE	Nitrofuran derivatives	935.24	981.97	1,019.51	1,073.19	1,152.40	1,210.89	1,323.77	1,387.68	1,502.39
	J01XX	Fosfomycin	64.76	74.26	48.00	35.71	26.28	20.78	17.80	11.01	1.99
NC	J01XX	Methenamine	389.51	356.69	350.35	296.88	282.20	253.34	249.14	256.85	157.83
	J01	**Total**	**207,280.44**	**203,691.77**	**194,522.04**	**194,923.13**	**189,674.87**	**194,167.12**	**196,231.93**	**195,651.06**	**197,753.38**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

NA = Not available. NC = Not classified.

TABLE C.8. Population demographics and availability of health care in Canada.

Province	Post-censal population estimates 2007[a]	Post-censal population estimates 2008[a]	Percentage (%) change in 2008	Population density/km^2 (2008)[b]
British Columbia	4,309,500	4,383,800	1.7	4.74
Alberta	3,513,100	3,595,900	2.4	5.60
Saskatchewan	1,000,100	1,013,600	1.3	1.71
Manitoba	1,193,900	1,206,100	1	2.18
Ontario	12,794,700	12,936,300	1.1	14.10
Québec	7,687,100	7,753,500	0.9	5.68
New Brunswick	745,600	747,100	0.2	10.47
Nova Scotia	935,900	936,600	0.1	17.56
Prince Edward Island	138,100	139,500	1	24.65
Newfoundland and Labrador	506,500	506,400	-0.2	1.35
Yukon	32,600	33,200	1.8	0.07
Northwest Territories	43,500	43,700	0.5	0.04
Nunavut	31,300	31,600	1	0.02
Canada	**32,932,000**	**33,327,300**	**1.2**	**3.66**

[a] Statistics Canada. Population by year, by province and territory. Available at: www40.statcan.ca/l01/cst01/demo02a-eng.htm. Accessed February 2010.

[b] Population density per square kilometre in 2007 was calculated on the basis of the population in 2007 and the land area in square kilometres reported by Statistics Canada at www40.statcan.ca/l01/cst01/phys01-eng.htm. Accessed February 2010.

TABLE C.9. Characteristics, production, and per-capita consumption of Canadian livestock.

Farmed animal species	Number of farms in 2006	Number of animals Jan. 1, 2007	Number of animals Jan. 1, 2008	Percentage change in 2008[a]	Product produced in 2008[b] (metric tonnes)	Per-capita consumption in 2008[c,d]
Cattle	**109,901[e]**	**14,155,000[f]**	**13,895,000[f]**	**-1.84**	**1,251,110[f]**	**Beef = 29.34 kg**
Beef cows	83,000	5,020,100	4,981,900	-0.76	Calves = 36,960	Veal = 0.99 kg
Dairy cows	17,515	994,800	984,300	-1.06		Fluid milk = 81.96 L
Heifers (≥ 1 year old)	72,929					Cream = 8.53 L
Heifers for beef replacement	45,407	587,100	595,000	1.35		Cheese = 12.33 kg
Heifers for dairy replacement	16,585	480,100	471,100	-1.87		
Heifers for slaughter or feeding	23,998	963,500	982,900	2.01		
Steers (≥ 1 year old)	36,695	1,145,200	1,101,600	-3.81		
Calves (< 1 year old)	98,107	4,719,600	4,531,400	-3.99		
Bulls (≥ 1 year old)	71,958	244,600	246,800	0.90		
Swine	**11,497[g]**	**14,907,000[h]**	**13,810,000[h]**	**-7.36**	**1,940,980[h]**	**Pork = 23.51 kg**
Sows and bred gilts	5,831	1,545,800	1,482,500	-4.09		
Boars	5,133	33,300	29,700	-10.81		
Nursing and weaner pigs	5,560					
Grower and finishing pigs	8,937					
Pigs < 20 kg		4,545,100	4,471,900	-1.61		
Pigs 20–60 kg		4,531,700	3,962,000	-12.57		
Pigs > 60 kg		4,251,100	3,863,900	-9.11		

Statistics from the 2006 CIPARS report are slightly different than those reported here. These changes were made to reflect updates in the 2007 Census of Agriculture report.

[a] Percentage change was calculated as ([2008 value – 2007 value] / 2007 value) X 100.

[b] Total cold dressed weight, not including edible offal.

[c] Statistics Canada. *Food Statistics 2009*. Cat. No. 21-020-XIE.
Available at: www.statcan.gc.ca/pub/21-020-x/21-020-x2009001-eng.pdf. Accessed November 2010.

[d] Food available for consumption (eviscerated).

[e] Statistics Canada. *Agriculture overview, Canada and the provinces – cattle and calves on Census Day, 2006 and 2001*.
Available at: www.statcan.ca/english/freepub/95-629-XIE/1/1.24.htm. Accessed March 2009.

[f] Statistics Canada. *Cattle Statistics 2010*. Cat. No.23-012-XIE, Vol 6, No .2.
Available at: www.statcan.gc.ca/pub/23-012-x/23-012-x2010001-eng.pdf. Accessed November 2010.

[g] Statistics Canada. *Agriculture overview, Canada and the provinces – pigs on Census Day, 2006 and 2001*.
Available at: www.statcan.ca/english/freepub/95-629-XIE/1/1.25.htm. Accessed March 2009.

[h] Statistics Canada. *Hog Statistics Third quarter 2010*. Cat. No. 23-010-XIE, Vol. 6, No. 3.
Available at: www.statcan.gc.ca/pub/23-010-x/23-010-x2010004-eng.pdf. Accessed November 2010.

TABLE C.9 (continued). Characteristics, production, and per-capita consumption of Canadian livestock.

Farmed animal species	Number of farms in 2006	Number of animals Jan. 1, 2007	Number of animals Jan. 1, 2008	Percentage change in 2008[a]	Product produced in 2008[b] (metric tonnes)	Per-capita consumption in 2008[c,d]
Poultry		**662,098,000**[i]	**663,130,000**[i]	**0.16**	**1,220,496**[i]	**Poultry = 38.08 kg** **Eggs = 9.93 kg**
Hens and chickens	22,712[j]	640,342,000	640,281,000	-0.01	Chicken = 1,040,577	Chicken = 31.66 kg
Broilers, roasters, and cornish hens	8,831					Stewing hens = 1.69 kg
Turkeys	3,174	21,756,000	22,849,000	5.02	Turkey = 179,919	Turkey = 4.72 kg
Sheep	**11,031**[k]	**879,100**[l]	**825,300**[l]	**-6.12**	**15,820**[l]	**Lamb and mutton = 1.15 kg**
Ewes	10,309	558,100	532,500	-4.59		
Rams	8,175	26,000	24,200	-6.92		
Lambs	9,117					
Replacement lambs		88,200	81,800	-7.26		
Market lambs		206,800	186,800	-9.67		
Fish						**Fish= 9.48 kg**
Salmon					Salmon = 104,070	Fresh and frozen fish and seafood = 4.91 kg
Trout					Trout = 5,843	Processed fish and seafood = 2.93 kg
Finfish					Finfish = 1,177	
Shellfish					Shellfish = 30,715	Shellfish = 1.12 kg

Statistics from the 2006 CIPARS report are slightly different than those reported here. These changes were made to reflect updates in the 2007 Census of Agriculture report.

[a] Percentage change was calculated as ([2008 value – 2007 value] / 2007 value) X 100.

[b] Total cold dressed weight, not including edible offal.

[c] Statistics Canada. *Food Statistics 2009*. Cat. No. 21-020-XIE.
Available at: www.statcan.gc.ca/pub/21-020-x/21-020-x2009001-eng.pdf. Accessed November 2010.

[d] Food available for consumption (eviscerated).

[i] Statistics Canada. Poultry and Egg Statistics April to June 2010. Cat. No. 23-015-XIE, Vol. 4, No. 2.
Available at: www.statcan.gc.ca/pub/23-015-x/23-015-x2010002-eng.pdf. Accessed November 2010.

[j] Statistics Statistics Canada. Agriculture overview, Canada and the provinces - poultry inventory on Census Day, 2006 and 2001.
Available at: www.statcan.ca/english/freepub/95-629-XIE/1/1.29.htm. Accessed March 2009.

[k] Statistics Canada. Agriculture overview, Canada and the provinces - sheep and lambs on Census Day, 2006 and 2001.
Available at: www.statcan.ca/english/freepub/95-629-XIE/1/1.26.htm. Accessed March 2009.

[l] Statistics Canada. Sheep Statistics 2010. Cat. No. 23-011-XI.
Available at: www.statcan.gc.ca/pub/23-011-x/23-011-x2009002-eng.pdf. Accessed November 2010.

[m] Statistics Canada. Aquaculture Statistics 2009. Cat. No. 23-222-X.
Available at: www.statcan.gc.ca/pub/23-222-x/23-222-x2009000-eng.pdf. Accessed November 2010.

TABLE C.10. Number of births, slaughtered animals, international imports and exports, and farm deaths of Canadian cattle, pigs, and sheep.

	Cattle[a]	Swine[b]	Sheep[c]
Births	5,299,900	34,084,300	807,200
Slaughters[d]	3,843,900	21,693,400	739,200
Percentage (%) change in slaughters in 2008[e]	36.24	2.01	-1.81
International imports	48,300	2,500	39,200
Percentage (%) change in imports in 2008[e]	-9.55	56.25	49.62
International exports	1614,300	9,316,300	0.00
Percentage (%) change in exports in 2008[e]	14.37	-7.13	-100.00
Deaths and condemnations	605,000	1,651,400	124,300
Percentage (%) change in deaths and condemnations in 2008[e]	-2.69	30.73	-4.82

[a] Statistics Canada. Cattle Statistics 2009. Cat. No.23-012-X, Vol. 8, No. 1. Available at: www.statcan.gc.ca/pub/23-012-x/23-012-x2008002-eng.pdf. Accessed November 2010.

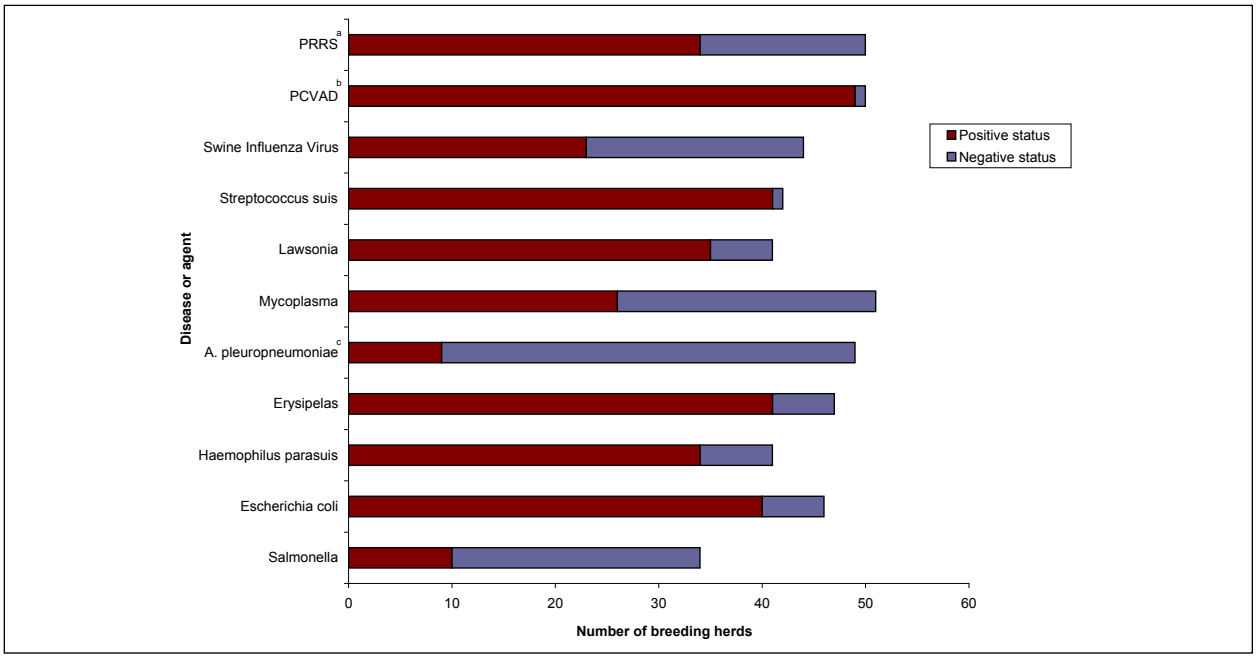
[b] Statistics Canada. Hog Statistics – Four quarter 2009. Cat. No. 23-010-X, Vol. 8, No. 1. Available at: www.statcan.gc.ca/pub/23-010-x/23-010-x2009001-eng.pdf. Accessed November 2010.

[c] Statistics Canada. Sheep Statistics 2010. Cat. No. 23-011-X, Vol. 9, No. 2. Available at: www.statcan.gc.ca/pub/23-011-x/23-011-x2010001-eng.pdf. Accessed November 2010.

[d] For swine data: represents slaughter but may include pigs destined for export (varies by province).

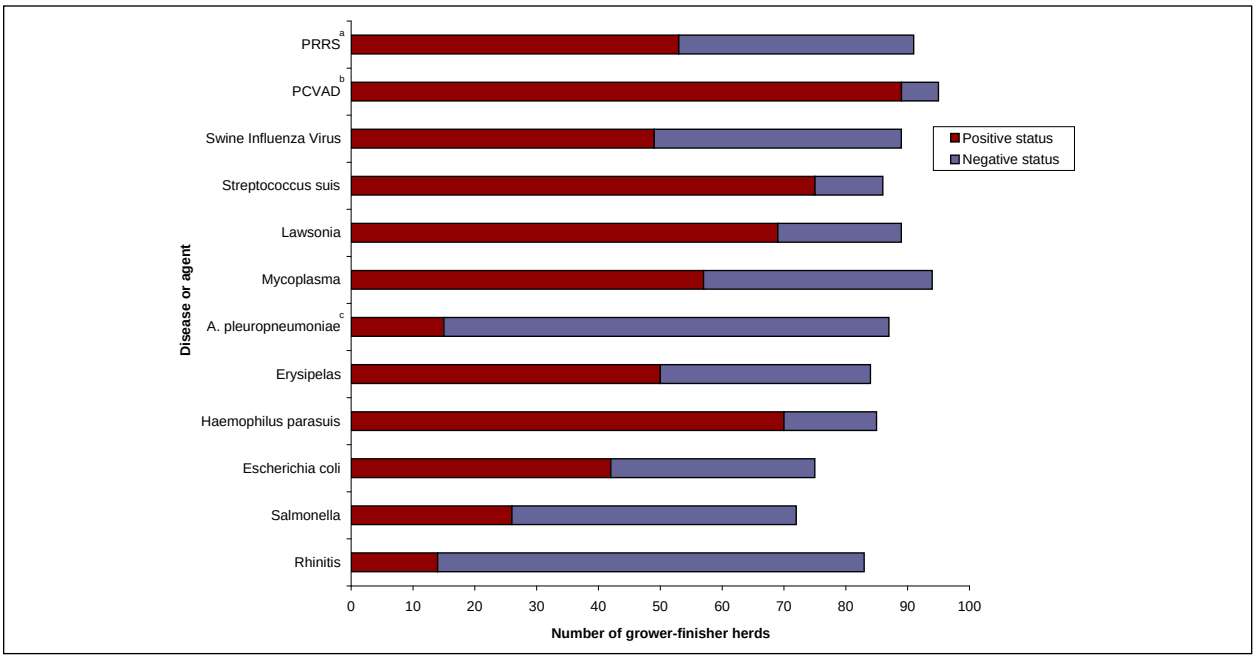
[e] Percentage change was calculated as ([2008 value – 2007 value]/2007 value) X 100.

FIGURE C.1. Numbers of breeding swine herds for which disease status (positive or negative) was reported, by disease; *Farm Surveillance*, 2008.



[a] PRRS = Porcine reproductive and respiratory syndrome. [b] PCVAD = Porcine circovirus. [c] *Actinobacillus pleuropneumonia*e.

FIGURE C.2. Number of grower-finisher swine herds for which disease status (positive or negative) was reported, by disease; *Farm Surveillance*, 2008.



[a] PRRS = Porcine reproductive and respiratory syndrome. [b] PCVAD = Porcine circovirus. [c] *Actinobacillus pleuropneumonia*e.

Appendix D – Additional Information

Abbreviations

General Abbreviations

A2C-AMP	Resistance to amoxicillin-clavulanic acid, cefoxitin, ceftiofur, and ampicillin
AARD	Alberta Agriculture and Rural Development
ACSSuT	Resistance to ampicillin, chloramphenicol, streptomycin, sulfisoxazole, and tetracycline
ACKSSuT	Resistance to ampicillin, chloramphenicol, kanamycin, streptomycin, sulfisoxazole, and tetracycline
AKSSuT	Resistance to ampicillin, kanamycin, streptomycin, sulfisoxazole, and tetracycline
AMU	Antimicrobial use
ATC	Anatomical Therapeutic Chemical
ATCC	American Type Culture Collection
BPW	Buffered peptone water
CAHI	Canadian Animal Health Institute
CCS	Canadian CompuScript
CFIA	Canadian Food Inspection Agency
CLSI	Clinical and Laboratory Standards Institute
CQA®	Canadian Quality Assurance
CTM	Close to market weight
DANMAP	Danish Integrated Antimicrobial Resistance Monitoring and Research Program
DDD	Defined daily dose
GSS	Global *Salmonella* Surveillance
IMS	Intercontinental Medical Statistics
ISO	International Standards Organization
LFZ	Laboratory for Foodborne Zoonoses
mCCDA	Modified cefoperazone charcoal deoxycholate agar
MHB	Mueller Hinton broth
MIC	Minimal inhibitory concentration
MRSA	Methicillin-resistant *Staphylococcus aureus*
MSRV	Modified semi-solid Rappaport Vassiliadis
NA	Not available
N/A	Not applicable
NC	Not classified
NML	National Microbiology Laboratory
OIÉ	Organisation Mondiale de la Santé Animale
PCVAD	Porcine circovirus-associated disease
PHAC	Public Health Agency of Canada
PPHL	Provincial Public Health Laboratory
PRRS	Porcine reproductive and respiratory syndrome
PT	Phage type
STL	*Salmonella* Typing Laboratory
USA	United States of America
VDD	Veterinary Drugs Directorate

Antimicrobials

AMC Amoxicillin-clavulanic acid
AMK Amikacin
AMP Ampicillin
AZM Azithromycin
CHL Chloramphenicol
CIP Ciprofloxacin
CLI Clindamycin
CRO Ceftriaxone
DAP Daptomycin
ERY Erythromycin
FLA Flavomycin
FLR Florfenicol
FOX Cefoxitin
GEN Gentamicin
KAN Kanamycin
LIN Lincomycin
LNZ Linezolid
NAL Nalidixic acid
NIT Nitrofurantoin
PEN Penicillin
QDA Quinupristin-dalfopristin
SSS Sulfisoxazole
STR Streptomycin
SXT Trimethoprim-sulfamethoxazole
TEL Telithromycin
TET Tetracycline
TIG Tigecycline
TIO Ceftiofur
TYL Tylosin
VAN Vancomycin

Canadian Provinces and Territories

AB Alberta
BC British Columbia
MB Manitoba
NB New Brunswick
NL Newfoundland and Labrador
NS Nova Scotia
NT Northwest Territories
NU Nunavut
ON Ontario
PEI Prince Edward Island
QC Québec
SK Saskatchewan
YT Yukon Territory

Glossary

Antimicrobial: Substance (including natural and synthetic products) that kills or inhibits the growth of organisms such as bacteria, fungi, viruses, or parasites. Throughout this report, the term "antimicrobial" is used to refer only to drugs effective against bacteria.

Antimicrobial resistance: Observed when the minimal inhibitory concentration of an antimicrobial is equal to or greater than the defined resistance breakpoint. Resistant bacteria are able to withstand the effects of an antimicrobial principally through 1 of these 4 mechanisms: 1) drug inactivation or modification by enzyme production, 2) adaptation of bacterial metabolism, 3) structural modification of antimicrobial targets and, 4) mechanisms to decrease drug permeability or increase drug elimination. Moreover, some bacteria have natural (or intrinsic) resistance to certain antimicrobials.

Co-resistance: Coexistence of 2 or more genes or mutations in the same bacterial strain, each of which confers resistance to a different class of drug. Also designated "associated resistance" (Aarestrup, 2006).

Cross-resistance: Situation in which resistance to 1 drug is associated with resistance to another drug, and that resistance is attributable to a single biochemical mechanism (Aarestrup, 2006). For more details, see Appendix C.3 in the 2005 CIPARS Annual Report.

Defined daily dose (DDD): Statistical measure of drug consumption developed by the World Health Organization to standardize comparisons of drug usage at international and other levels, independently of cost or drug formulation.

Minimal inhibitory concentration (MIC): Lowest antimicrobial concentration required to inhibit bacterial growth after an overnight in vitro incubation. The MIC is used to confirm or monitor antimicrobial resistance in bacteria. Resistance is said to exist when the MIC is higher than the defined breakpoint of resistance for a given bacterial isolate.

Multidrug resistance: Used in this report to describe resistance to more than 1 structurally-unrelated class of antimicrobials in a given bacteria isolate, regardless of the resistance mechanisms involved. Multidrug resistance (also referred to as multiple drug resistance or multiresistance) can result from bacterial mechanisms of cross-resistance and/or co-resistance. For more details, see the 2005 CIPARS Annual Report, Appendix C.3.

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